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# Determination of Emission Rates of Hydrocarbons from Indigenous Species of Vegetation in the Tampa/St. Petersburg, Florida Area. Tampa Bay Area Photochemical Oxident Study

**Washington State Univ., Pullman**

**Prepared for**

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# Tampa Bay Area Photochemical Oxidant Study

## Final Appendix C

## Determination of Emission Rates Of Hydrocarbons From Indigenous Species Of Vegetation In The Tampa/St. Petersburg Florida Area.

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This report describes the methodology used to develop a natural hydrocarbon emission inventory for the Tampa/St. Petersburg Florida area. Hydrocarbon emissions for more than 600 vegetation samples were collected and quantified chromatographically in terms of Total Nonmethane Hydrocarbons, Paraffins, Olefins, Aromatics, and Methane. The report also includes a detailed study of vegetation type, amount, and distribution over the study area. Hourly emission factors were determined for each hydrocarbon component and species. These emission factors are coded onto a 1.5 x 1.5 km grid measuring 54 x 40 which covers the study area. Emission rates for various Florida vegetation species, associations, and land use categories are given.

The principal investigator calculates that natural emissions during the summer months are approximately 160 metric tons per day, or an average emission flux of approximately 1350 ug/m$^2$/hr during the daytime (30°C) and 700 ug/m$^2$/hr during the nighttime (25°C). Isoprene, the single largest nonmethane emission component, is approximately 18% of the daily TNMHC emission. The next largest emission component is a-Pinene (10% of daily TNMHC emission). Methane emissions were calculated to be approximately 33% of the TNMHC plus methane total. The data is recorded on computer tape which contains all field data, the emission factors, and the computer programs used to generate the hydrocarbon emission inventory.

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16. ABSTRACT

The methodology used to develop a natural hydrocarbon emission inventory for a 60 X 81 km area including Tampa and St. Petersburg, Florida is described. The inventory is based upon more than 600 emission rate samples collected from vegetation, surface water and pastures between the months of April and August, 1977. Emission rates in terms of total non methane hydrocarbons (TNMHC), paraffins, olefins, aromatics, methane, and each major emission component are presented for the major vegetation species, associations and land use categories which occurred in the study area. Hourly emission factors were calculated for each of the 2,160 1.5 km X 1.5 km grids in the study area and coded onto a computer tape.

The inventory estimates the summer biogenic emissions to approach 1025 $\mu g/m^2/hr$ or 160 metric tons/day. Isoprene is 18% of the TNMHC, $\alpha$-pinene is about 10%. Evergreen forests occupy approximately 10% of the total study area and contribute about 35% of the total daily emissions.

The emissions are fairly uniform with respect to time and space, therefore, low ambient levels of the natural hydrocarbons are expected in ambient air.

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By: P. R. Zimmerman

Prepared For: Environmental Protection Agency
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Attention: Ron McHenry

1b

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Don Stearns, Phil Sweany and Bob Watkins collected and analyzed many of the field samples. They also assisted in data reduction and in the preparation of the final report.

Dianne Rochleau did much of the background research for the leaf biomass section of this report.

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# ABSTRACT

This report describes the methodology used to develop a natural hydrocarbon emission inventory for a 60 x 81 km region which includes the Tampa and St. Peterburg Florida. As part of the study a field program was conducted in which over 600 emission rate samples were collected and analyzed. The hydrocarbon emissions were quantified chromatographically in terms of Total Nonmethane Hydrocarbons, Paraffins, Olefins, Aromatics, Methane, and for each major hydrocarbon peak. The report also includes a detailed study of the distribution and quantitation of the vegetation in the area. Hourly emission factors were determined for each hydrocarbon component and species. These emission factors have been coded onto a computer tape for each of the 2,160 1.5 x 1.5 km grids in the study area.

The inventory calculates that natural emissions during the summer months approximate 160 metric tons/day. This is equal to an average emission flux of approximately 1350 $\mu g/m^2$ hr during the daytime (30°C) and 700 $\mu g/m^2$ hr during the nighttime (25°C). Isoprene is the single largest nonmethane emission component, and is approximately 18% of the daily TNMHC emission. The next largest emission component is $\alpha$-Pinene (10% of daily TNMHC emission). Methane emissions were calculated to be $\sim$33% of the TNMHC plus methane total. The emissions are distributed fairly uniformly throughout the study area with respect to time and space; however, "evergreen forests" which occupy approximately 10% of the total study area account for about 35% of the non-methane hydrocarbon emissions.

Appendicies are included which list emission rates by vegetation species, emission factors for vegetation types (associations and land use categories), and total daily emissions for each vegetation type.

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# INTRODUCTION

The regional nature of pollutant episodes has been well documented in the last few years. High pollutant levels, especially $O_3$, have been measured in rural areas well away from significant emission sources, (Sandberg, et al., 1978), Ripperton et al., 1977). Evidence has accumulated that indicates oxidant precursors generated in urban centers can be transported into these rural regions, however it has also been shown that photooxidation of natural hydrocarbons can produce significant quantities of ozone, (Westberg, 1977). Thus it is unclear at the present time what part each of these ozone producing mechanisms plays.

In order to define the importance of the natural production of hydrocarbons in a specific region a good estimate of natural hydrocarbon emissions is essential. Early literature estimates of biogenic hydrocarbon production indicate that natural sources of oxidant precursors may be significant, (Went, 1960). However, recent studies aimed at identifying terpene emissions in the vicinity of forested areas have found minimal amounts of these natural hydrocarbons, (Lonneman, et al., 1978).

Many rural and urban areas presently routinely exceed government air quality standards set for oxidant concentrations. As a result, large-scale control strategies aimed at local anthropogenic source emissions have been proposed. Since no adequate estimate of natural biogenic oxidant precursors is available, the potential effectiveness of the control strategies is subject to debate. (Koziar and Becker, 1977).

This report describes the procedure used to more reliably estimate the magnitude of the contribution of biogenic hydrocarbon emissions to the ambient air in the Tampa Bay/St. Petersburg area and the results of an intensive field study conducted by WSU in the Tampa/St. Petersburg area between the months of April and August, 1977.

It should be noted that the biogenic emission rates quoted in this report are not meant to be used as a direct comparison with anthropogenic emission rates. Direct comparisons are inappropriate since biogenic emissions differ fundamentally from anthropogenic emissions with respect to their chemical characteristics, emission densities and resultant ambient concentrations (Westberg, 1977; Zimmerman, 1977).

## OBJECTIVES

The research program described in this report was initiated in February 1977, by Region IV of the Environmental Protection Agency, with the following objectives:

1. To develop and quantify emission rates for the dominant species of the following natural hydrocarbon sources in the Tampa/St. Petersburg area:
    a. Decaying vegetation in the coastal intertidal areas
    b. Dominant grass of the marine grass beds
    c. Production of hydrocarbons from the surface waters of Tampa Bay
    d. Forest type group of Oak-Gum-Cypress
    e. Forest type group of Long-Leaf Pine
    f. Improved pastures
    g. Palmetto
    h. Dominant Mangrove species
    i. Native grass (unimproved pastures)
    j. Citrus trees
    k. Representative shrubs
    l. Forest type group of Oak, Hickory
    m. Representative row crops

2. To identify and quantify the emission rate of each major hydrocarbon peak for each vegetative type and to group the emissions into the four chemical classes of:
    a. methane
    b. paraffins
    c. olefins
    d. aromatics

3. To develop April-August biogenic emission factors for each 1.5 x 1.5 km grid section within the approximately 61 by 80 km study area which included Tampa and St. Petersburg, Florida.

# 1. METHODOLOGY

This section briefly describes the techniques used for collecting emission rate samples from vegetation, soil-pasture and water surfaces. Details of the sample analysis, instrument calibration, and emission rate quantitation are also discussed.

## 1.1 SAMPLING METHODOLOGY

The technique used to determine the emission rates from vegetation, soil leaf-litter and surface water has been described in detail elsewhere (Zimmerman, 1979).

The method can be classified as a semi-static enclosure technique. Figure 1.1-a illustrates the equipment and procedure involved in collecting an emission sample from vegetation.

A common indoor-outdoor type thermometer is used to monitor ambient air temperatures and bag air temperatures simultaneously during sampling. Before the bag is placed around a branch the "outdoor" temperature sensor is placed along the branch. If sampling occurrs in bright sunlight the sensor is placed so that it is not in the direct incident light (i.e. it is placed below a leaf or branch for shade). The "indoor" thermometer is hung in the shade on a nearby limb.

Next, sample, evacuation and zero air lines are placed along the branch. Lines used for zero air and for sampling are connected to a sample manifold

# VEGETATION EMISSION SAMPLE COLLECTION SYSTEM

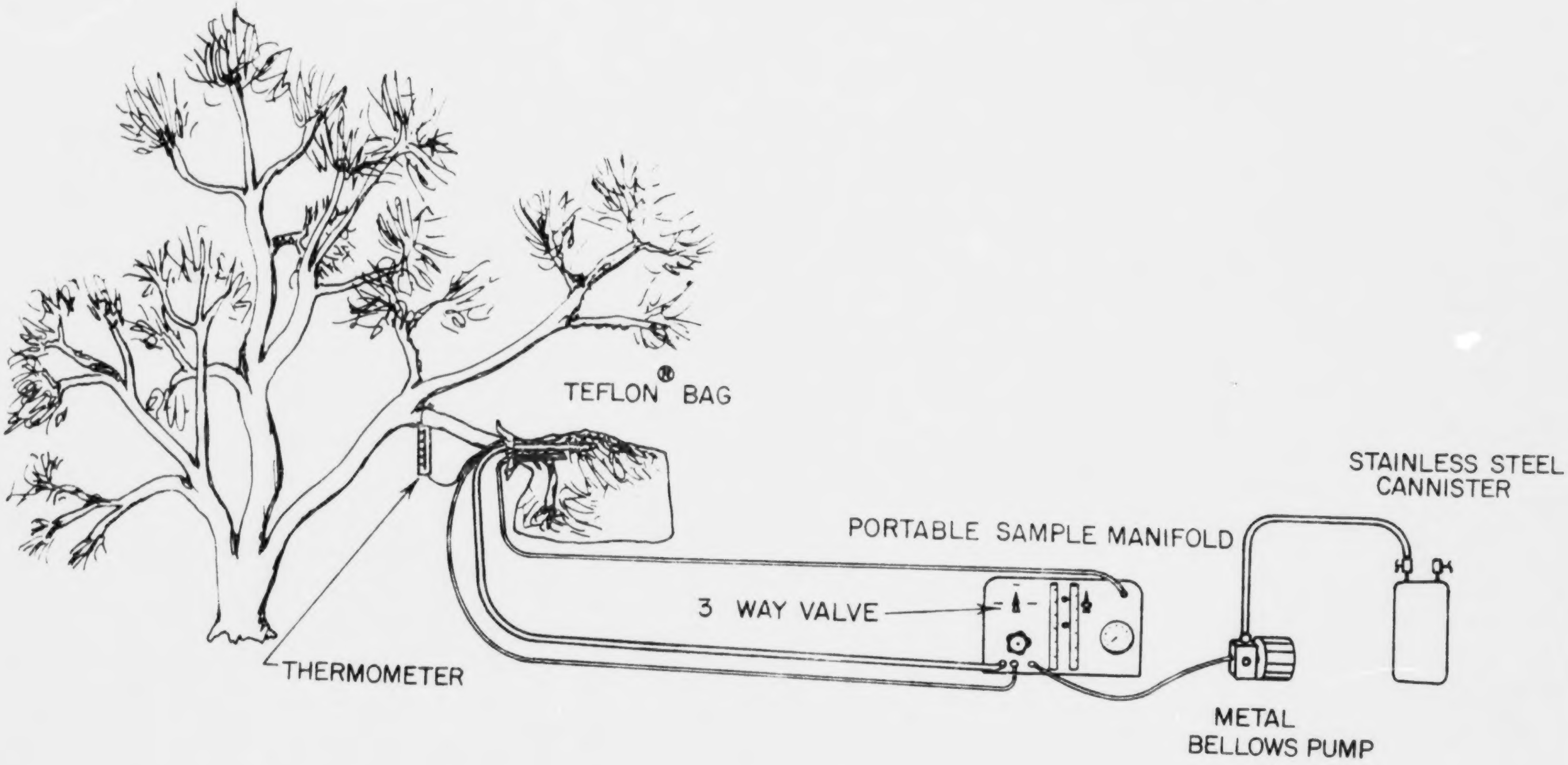

TEFLON® BAG
THERMOMETER
3 WAY VALVE
PORTABLE SAMPLE MANIFOLD
STAINLESS STEEL CANNISTER
METAL BELLOWS PUMP

Figure 1.1-a

equipped to regulate zero air pressure, zero air and sample flow rates (Figure 1.1-b).

A large Teflon bag, ( 1m x 1.2m) with a capacity of approximately 120 ℓ (open at one end), is then carefully placed over the branch. The bag is sealed at its base by wrapping it with a strip of Velcro® sewn so that the "fuzzy" side and the "hook" side face opposite directions.

As much ambient air as practical (without damaging the vegetation) is quickly removed from the bag, and a sample of the air is pumped via a 12 volt metal-bellows pump into a 6.6 liter electropolished stainless steel canister. This is the "background sample." It contains the contribution to the bag from hydrocarbons present in ambient air at the time of sampling plus emissions from the branch. After the background sample is collected the bag is quickly inflated with zero air at the rate of 10 liters/minute for six minutes. The zero air has a $CO_2$ content of approximately 365 ppm and no hydrocarbons.

Next the emission rate sample is collected at approximately 2 liters per minute, while zero air continues to flow into the enclosure at 2 liters per minute. The total enclosure time is less than 15 minutes.

Leaf litter and pasture samples are collected in a similar manner except that the enclosure technique utilizes a sealing ring and stainless steel bag collar, Figure 1.1-c. To collect a pasture sample the sealing ring is driven into the soil to act as a seal and the bag collar is placed in the center of the sealing ring. After the collar and ring are placed, the Teflon bag is attached to the collar by means of a wide elastic strap. The remainder of the sample collection procedure is identical to that for vegetation.

FIGURE 1.1-b

PORTABLE SAMPLE MANIFOLD

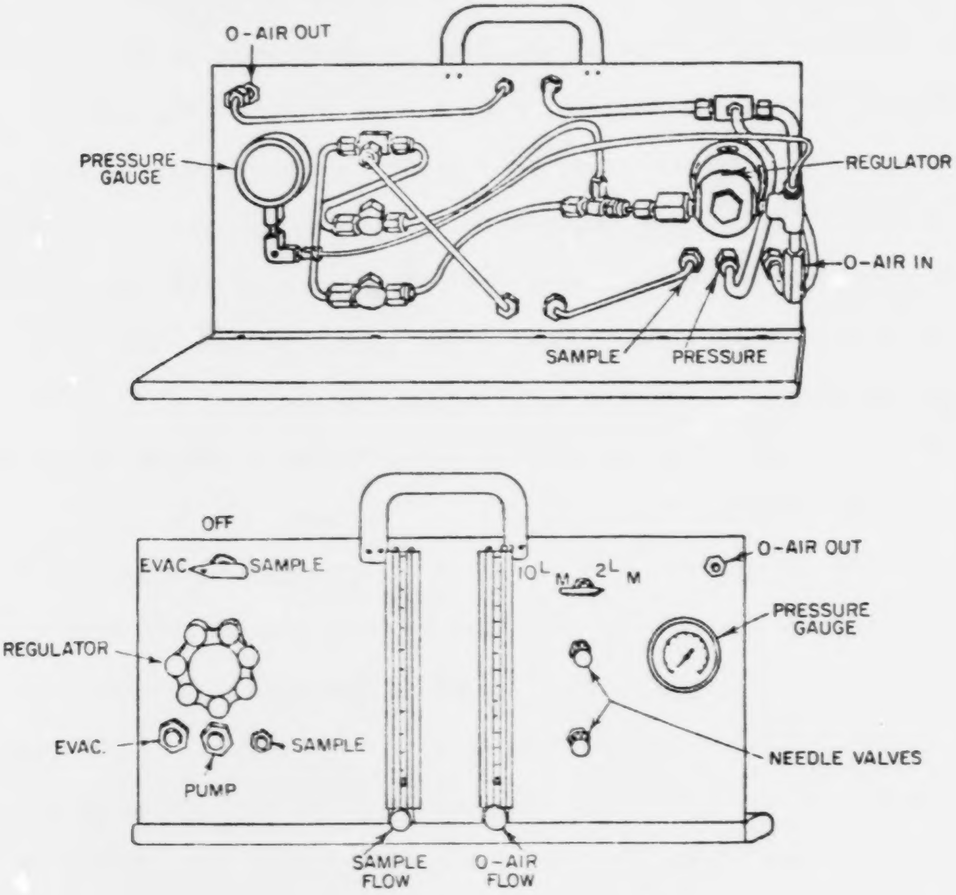
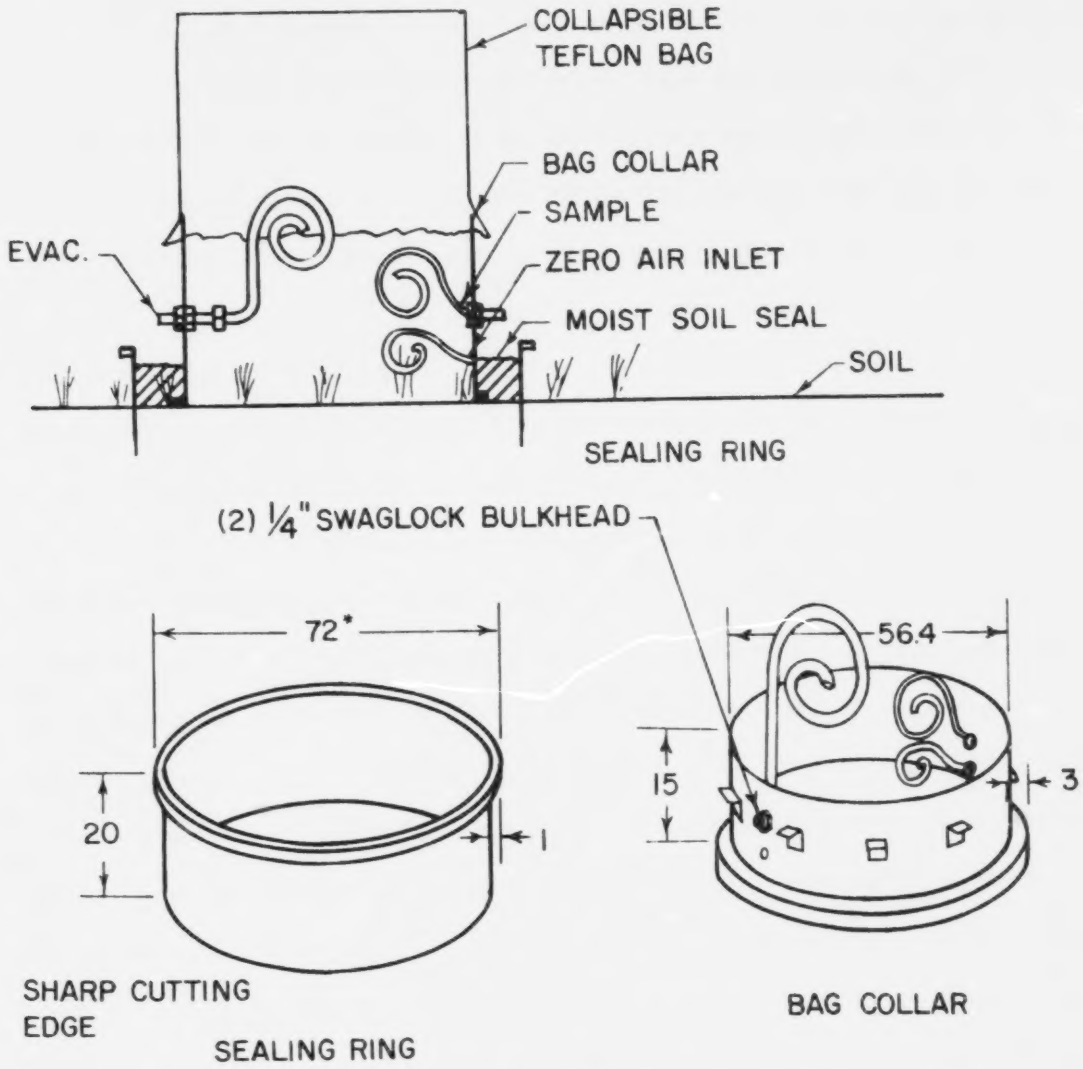

O-AIR OUT
PRESSURE GAUGE
REGULATOR
O-AIR IN
SAMPLE
PRESSURE
OFF
EVAC
SAMPLE
10 L M
2 L M
O-AIR OUT
PRESSURE GAUGE
REGULATOR
EVAC.
PUMP
SAMPLE
NEEDLE VALVES
SAMPLE FLOW
O-AIR FLOW

Figure 1.1-c

# SOIL LEAF-LITTER SAMPLING SYSTEM


COLLAPSIBLE TEFLON BAG
BAG COLLAR
SAMPLE
EVAC.
ZERO AIR INLET
MOIST SOIL SEAL
SOIL
SEALING RING
(2) ¼" SWAGLOCK BULKHEAD
72*
20
1
56.4
15
3
SHARP CUTTING EDGE
SEALING RING
BAG COLLAR

**all dimensions in centimeters*

To collect samples from Tampa Bay, the Gulf of Mexico and from fresh water, a floatation ring made of two water-ski belts sewn together is strapped around the bag collar, Figure 1.1-d. The standard sample collection procedure is then followed. For many of the samples which utilize the bag collar, virtually all of the ambient air can be removed from the bag. This, therefore, eliminates the need to collect a background sample.

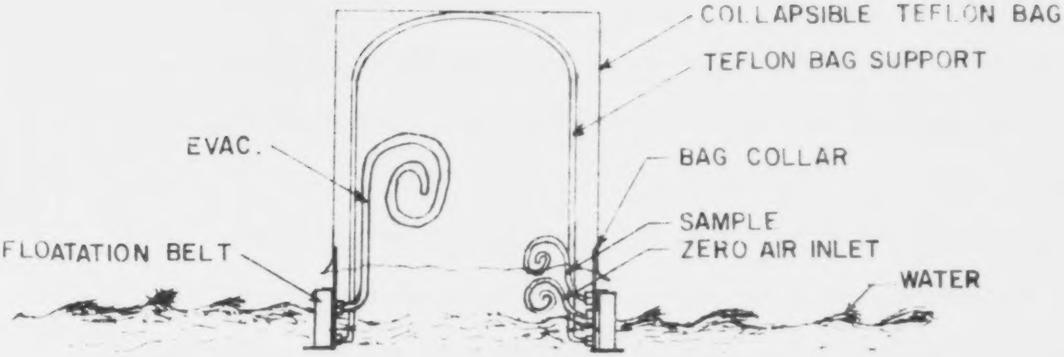
Periodic sample blanks are collected to insure the integrity of the sampling equipment and analytical procedures. The sample blanks are collected using the identical procedures as those used to collect vegetation samples, except no vegetation is enclosed.

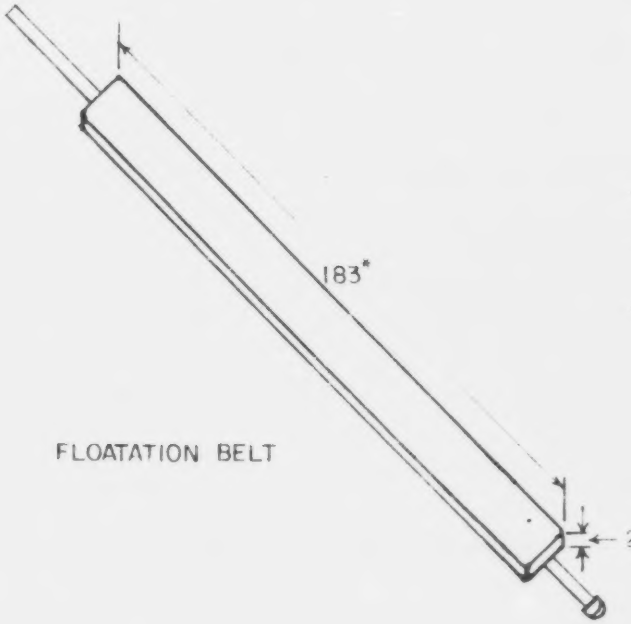
The net emission from the vegetation, pasture leaf litter or surface water enclosed is equal to the difference between the hydrocarbon content of the bag after enclosure, as represented by the background sample, and the hydrocarbon content of the bag after the addition of zero air, as represented by the emission rate sample. This net emission is converted to an emission rate by dividing by a unit of time and a unit of foliage or area.

For vegetation samples, leaf dry weight of the branch enclosed (leaf biomass) was used as a unit of foliage. Therefore, the raw emission rates for vegetation are given in micrograms hydrocarbon (HC) emission per gram leaf biomass per hour (μg/g/hr). Leaf biomass was determined by clipping the branch at the point of enclosure, separating the leaves and drying them in an oven at 70°C until they reached a constant weight. For the pasture, marine, and aquatic samples and some row crops (flat samples) the emission rates were calculated in terms of μg/unit surface area covered/unit time ($\mu g/m^2/hr$). The emission rates for most of the flat sample categories were small. Since the samples included emissions from any vegetation enclosed

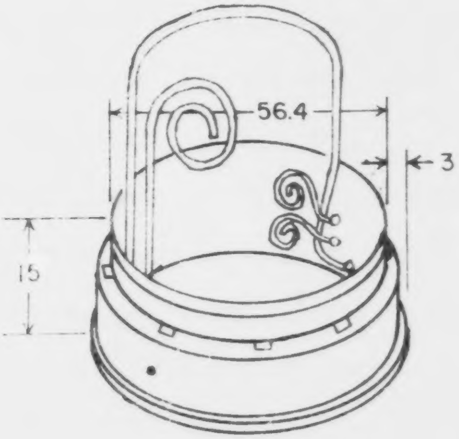
Figure 1.1-d

# SURFACE WATER SAMPLING SYSTEM


COLLAPSIBLE TEFLON BAG
TEFLON BAG SUPPORT
EVAC.
BAG COLLAR
SAMPLE
ZERO AIR INLET
FLOATATION BELT
WATER



FLOATATION BELT



BAG COLLAR

*all dimensions in centimeters

(i.e. grass or phytoplankton) as well as from the substrate itself (soil or water) it was felt that the results would be more meaningful if wide ranges of pasture row crops and water conditions were sampled and emissions were related directly to ground or water surface area.

Throughout this report the emission rates reported are in terms of μg of each hydrocarbon compound. A conversion factor to micrograms carbon can be calculated from the ratio of the molecular weight of the hydrocarbon to the molecular weight minus the weight of the hydrogen atoms. Thus for the terpenes and isoprene the ratio is 0.88; therefore, μg hydrocarbon x 0.88 = μg carbon.

Figure 1.1-e shows the formula for calculating emission rates. This formula was applied to the determination of each individual hydrocarbon emission rate, as well as to each major hydrocarbon group. As the formula shows, the emission rates for vegetation were measured in terms of micrograms emission/unit time/unit leaf biomass. This emission rate was then converted to an emission factor or flux estimate by multiplying by a leaf biomass/unit ground area factor. For "flat samples" no conversion was necessary.

Figure 1.1-f illustrates the field data format used when collecting emission rate samples. Sample variables were recorded so that correlations with trends in emission rates might be determined at a later date. If the vegetation species sampled was not known, leaves were taken to local experts for positive identification.

## 1.2 ANALYTICAL METHODOLOGY

Columns and operating conditions are shown in Table 1.2-a. Methane, Ethylene, Ethane and Acetylene quantitation was determined using column Number 1. Column Number 2 was used for the analysis of $C_2$ - $C_6$ hydrocar-

Figure 1.1-e Emission rate formula

$$ER = \frac{C_{ss}\ (Zv + Ve) - C_{sb}\ Ve}{(Sa)\ (\Delta T_1)}$$

where:

$C_{ss}$: ($\mu g/m^3$) equals the TNMOC measured for the emission sample

$C_{sb}$: ($\mu g/m^3$) equals the TNMOC measured for the background sample

$Zv$: ($m^3$) equals the total volume of zero air put into the enclosure

$Sa$: (g) equals the dry weight of the leaves (leaf biomass)

$\Delta T_1$: (min) equals the total emission time. This is the time interval between the background sample and the emission sample.

$Ve$: ($M^3$) equals the dead volume of the bag when collapsed around the branch = $\frac{ZV}{C_{sb}'/C_{ss}')-1}$

$C_{sb}'$ and $C_{ss}'$ are equal to the concentration of a non-emitted tracer in the background and sample respectively. For this study acetylene was used since it was not found to be an emission product.

Note: Hydrocarbon emissions were calculated in terms of $\mu g$ hydrocarbon ($\mu g$). To convert to $\mu g$ carbon ($\mu gC$) for terpenes and isoprene, multiply by 0.88 (see text).

bons. The Durapak low-k column (Column #3) was used for the routine analysis of $C_4$ - $C_{12}$ hydrocarbons. In addition, each major species which was sampled extensively was also analyzed on the SE-30 glass capillary column (#5). This column gives better separation for purposes of peak identification; however, it was not known at the time that field sampling was performed if oxygenates would elute from the column in quantifiable peaks.

Samples of each major vegetation type were also sent to Pullman for analysis via gas chromatograph-mass spectrometer (GC-MS) to confirm the tentative field identification of the major hydrocarbons. The analysis showed that most of the tentative field identifications were correct.

### 1.2.1 Standardization

Each GC was standardized daily. A specially prepared standard certified by Scott Laborato[illegible]c., was used. The standard contained 0.299 ppm methane, 0.202 ppm ethylene, 0.213 ppm acetylene and 0.204 ppm neo-hexane. For the light hydrocarbon and heavy hydrocarbon G.C.'s 500 ml of the standard was introduced into the freeze-out loop and the area response to neo-hexane as determined by the Perkin Elmer PEP-1 Mini-computer was calculated as follows: 500 ml of 0.204 ppm neo-hexane = 359ng, (compound). Therefore the response factor is equal to 359ng/peak area of standard. The reproducibility of the injection procedure was better than one percent. The response factors for each instrument remained constant throughout the study period. The quantitation of ethane, ethylene, acetylene and methane was calculated on an individual concentration/peak height basis using the same Scott standard. This was done because we were operating five GC's and only four computer interfaces were available.

Figure 1.1-f. Field data format

Date 4-28 Sample # 151 Can # 169 Background<br>87 Emission

Location West U.S.F. Campus along Fowler Barom --------

Sample Type: Slash Pine

Enclosure: Teflon Bag number E

Site description: Sandy soil grassy, dry, Pine Oak Forest type, open canopy

Weather, general: clear, hot, some wind

Weather, site filtered sunlight Cloud cover 0% Ha (ambient air temp.) 27°C

Wind: direction SW speed 2-7 mph gust 15 mph

Vegetation: describe type, age, physiological state. 30' tall, moss on limbs 10" D.B.H. 20 years old growth fair, some frost damage.

Litter: Type pine needles

Incorporation ----- Depth -----

Soil: Moisture dry ph ----- Temp. -----

Describe sandy, grass understory.

Time at encl. $T_0$ 1311, Time End Bkgd. $T_1$ 1317 Start flush, $T_2$ 1317

End flush, $T_3$ 1323, Start purge, $T_4$ 1323 Start sample, $T_5$ 1323

End Sample, $T_6$ 1326 Sample rate l/min. 2.1

Flush flow rate ZF(l/min.) 10 Purge flow rate Zp(l/min) 2.0

Encloses sample temp. 29°C Can pressure 10 psig

COMMENTS: Ve estimated at 30 liters collected by Don Stearns

$\Delta T_1 = 9$, $\Delta T_2 = 6$, $\Delta T_3 = 3$, Zv = 0.066

Table 1.2-a. HYDROCARBON ANALYSIS CONDITIONS

| Compound | Instrument | Operating Conditions |
|---|---|---|
| Ethylene<br>Ethane<br>Acetylene<br>Methane | P.E. 3920 Isothermal FID GC. | 1. Column: 10' x 1/8" OD Porapak Q<br>Carrier: He 80 psig, 7 ml/min.<br>Hydrogen: 22 psig<br>Compressed Air: 50 psig<br>Oven: 65°C (30°C for $CH_4$)<br>Total Run Time: 10 min.<br>Sample Size: 100ml (5ml for $CH_4$) |
| Light Hydrocarbon $C_2$-$C_6$ | P.E. 3920 Temp. Prog. FID GC and/or HP 5711 A Temp. Prog. FID GC with Dual Electrometer Option. | 2. Column: 20' x 1/16" OD Durapak N-Octane<br>Carrier: He 90 psig, 6 ml/min<br>Hydrogen: 40 psig<br>Compressed Air: 50 psig<br>Oven: -70°C to 65°C<br>Delay time: 4 min<br>Program rate: 16°/min.<br>Total Run Time: 40 min.<br>Sample size: 500ml |
| Heavy Hydrocarbon and Oxygenates $C_4$-$C_{12}$ | P.E. 3920 and/or P.E. 990 Temp. Prog. FID GC. | 3. Column: 10' x 1/8" Durapak Low-K carbowax 400<br>Carrier: He 90 psig, 8 ml/min.<br>Hydrogen: 40 psig<br>Compressed air: 50 psig<br>Oven: -20 to 100°C<br>Delay Time: 2 min.<br>Program Rate: 8°/min.<br>Total Run Time: 20 min<br>Sample size: 500ml |
| Heavy Hydrocarbon $C_4$-$C_{12}$ | P.E..3920 Temp. Prog. FID GC and/or 990 Temp. Prog. FID GC. | 4. Column: 200' SCOT OV-101, 10' x 1/16" OD Durapak Low-K, Carbowax 400 precolumn<br>Carrier: He 90 psig, 5 ml/min<br>Hydrogen: 40 psig<br>Compressed Air: 50 psig<br>Oven: 0°C to 100°C Temp. Prog.<br>Delay Time: 6 min.<br>Program rate: 6°/min<br>Total Run Time: 60 min.<br>Sample size: 500ml |
| | | 5. Column: 30 m SE 30 Glass Capillary<br>Carrier: He 90 psig, 1 ml/min.<br>Oven: -30 to 80°C Temp. Prog.<br>Delay Time: 8 min.<br>Program rate: 4°/min<br>Total Run Time: 50 min.<br>Sample size: 500 ml |

A qualitative standard was used to determine the retention time of $C_2$ - $C_{12}$ compounds for identification purposes. The standard was made by injecting microliter amounts of liquid samples of each compound shown in Table 1.2.2-a and 1.2.2-b into an evacuated 25 ℓ glass carbouy. The container was then pressurized to about 5 psig with clean air. This mixture was run periodically to monitor column separation performance and elution time. In addition, WSU maintains a large file of the relative retention times of a wide variety of compounds for different column types. If a large peak was noted which was not present in the routine qualitative standard, its identity was tentatively made with the aide of these files. A few of the unknown compounds which were present for many vegetation samples but did not match the retention time of the known standards were determined via GC-MS analysis upon our return to the Pullman laboratory. Some compounds could not be identified. These unknowns were numbered and then retention times were recorded so that future identification might be possible.

### 1.2.2 Quantitation

The light hydrocarbon and heavy hydrocarbon GC's were interfaced with a Perkin Elmer PEP-1 Mini Computer. The computer listed the peak areas and retention times of each peak analyzed. The chromatograms were also recorded on strip charts.

For each sample, emission rates were determined for the major hydrocarbon groups of paraffins, olefins and aromatics. In addition emission rates of methane and of each of the major hydrocarbon peaks which was greater than five percent of the non-methane hydrocarbon total (TNMHC) were quantified for each sample.

For most vegetation types the chromatogram consisted of five or six major hydrocarbon components plus as many as one hundred very small peaks. It was

## Table 1.2.2-a ROUTINE LIGHT HYDROCARBON STANDARDS

| Compound |
|---|
| *Ethane |
| +Ethylene |
| +Acetylene |
| *Propane |
| +Propene |
| *Isobutane |
| *n-Butane |
| *2,2-Dimethylpropane |
| +Propyne |
| +I-Butene |
| +IsoButene |
| +2-Methylbutene |
| +trans-2-Butene |
| *n-Pentane |
| *Clyclopentane |
| +1-Pentene |
| *2,2-Dimethylbutane |
| *2-Methylpentane |
| +Trans-2-Pentene |
| +3-Methyl-1-Butene |
| *3-Methylpentane |
| *cis-2-Pentane |
| *Methylcyclopentane |
| *n-Hexane |
| +Isoprene |
| *Cyclohexane |

* Paraffins
+ Olefins
- Aromatics

## Table 1.2.2-b ROUTINE HEAVY HYDROCARBON STANDARDS

| | Class |
|---|---|
| 2,3-DimethylButane | Parrafins |
| 2-MethylPentane | |
| 3-MethylPentane | |
| n-Hexane | |
| 2,4-DimethylPentane | |
| 2,3-DimethylPentane | |
| 3-MethylHexane | |
| n-Hentane | |
| 2,2,4-TrimethylPentane | |
| 2,4-DimethylHexane | |
| 2,5-DimethylHexane | |
| 2,3,4-TrimethylPentane | ↓ |
| Toluene | - |
| 3-MethylHextane | |
| n-Octane | |
| 2,2,5-TrimethylHexane | ↓ |
| EthylBenzene | Aromatics |
| p-Xylene | |
| m-Xylene | |
| o-Xylene | |
| Styrene | ↓ |
| α-Pinene | + |
| β-Pinene | + |
| n-Nonane | * |
| IsopropylBenzene | Aromatics |
| n-PropylBenzene | |
| 1-Ethyl-2-MethylBenzene | |
| 1,3,5-TrimethylBenzene | ↓ |
| Myrcene | + |
| 1,2,4-TrimethylBenzene | - |
| n-Decane | * |
| $\Delta^3$-Carene | + |
| TerButylBenzene | - |
| d-Limonene | + |
| β-Phellanderene | + |
| Sec-ButylBenzene | - |
| Terpinolene | + |
| 1,2-DiethylBenzene | Aromatics |
| 1,3-DiethylBenzene | |
| 1,4-DiethylBenzene | |
| n-ButylBenzene | ↓ |
| n-Undecane | * |

*Parafins
+Olefins
-Aromatics

Note: All small peaks which eluted within the arrows were assumed to belong in the class named. Exceptions include those marked. Also, all large peaks were specifically identified by matching the elution time with known qualitative standards. This list only includes the compounds in the qualitative standard which was run periodically in order to verify column performance (See text).

thus impractical to attempt to identify each component and to calculate its emission rate. The following scheme was therefore used to quantify the emission components into their respective hydrocarbon groups:

TNMHC: The total of the light hydrocarbon analysis to (and including) propane plus the total of the heavy hydrocarbon analysis. If large peaks which eluted after propane were noted in the light hydrocarbon analysis, they were identified by matching their retention times with the known standards and each was grouped into its appropriate class. Usually, however there were virtually no peaks which eluted after propane on the light hydrocarbon analysis. All of the peaks which eluted after propane also eluted in the early part of the heavy hydrocarbon analysis. Although the peaks were not separated sufficiently for peak identification purposes, the TNMHC calculated by adding the individual light hydrocarbon peaks to the non-overlapping heavy hydrocarbon peak total matched the TNMHC calculated from the total of the light hydrocarbons to (and including) propane plus the total of the heavy hydrocarbons. Since the second procedure facilitated the speed of data reduction, it was used in this study to calculate TNMHC.

Paraffins: The total of the paraffins in the light hydrocarbon analysis to propane plus all of the peaks from the heavy hydrocarbon analysis which eluted before ethyl benzene, plus n-nonane and n-decane, (except for isoprene, benzene and toluene). While it was recognized that ethylene and acetylene were olefins, ethylene emissions were very small and no acetylene emission from vegetation was ever noted.

Olefins: The sum of all of of the terpenes plus isoprene.

Aromatics: Everything which eluted after n-octane with the exceptions of n-nonane, n-decane and the terpenes.

The light and heavy qualitative hydrocarbon standards which were used to establish elution order are listed in order of increasing retention times in Table 1.2.2-a and 1.2.2-b.

Some peaks which appeared in each chromatogram were subsequently determined by gas chromatographic-mass spectrometric analysis to be the result of column bleed. These peaks were then omitted. Broad tailing peaks were consistently associated with specific sample groups such as Bay and Gulf samples. These peaks, which occurred at specific elution times, were most likely due to the presence of sulfur compounds, however they could also have been caused by oxygenated compounds. It is also possible that the peaks were column bleed components caused by something in the samples. Since the character of the compounds responsible for these tailing peaks could not be determined, their areas were subtracted from the nonmethane hydrocarbon total (TNMHC) for each chromatogram.

Early in the sampling program the G.C. analysis was allowed to continue until the expected elution time of the $C_{15}$ compounds. Since no quantifiable peaks occurred after approximately $C_{12}$, and since the analytical procedure was the primary bottleneck in the sampling program, subsequent chromatograms were terminated at $\sim C_{12}$.

After the analysis was complete the sample canisters were recycled by purging with clean dry air at 10 liters per minute. At the same time the "cans" were heated to 70°C. This treatment continued for approximately 12 hours. The cans were then evacuated to a pressure of 30 microns or lower prior to being reused for sampling. Blank analysis of the can contents confirmed that the procedure did an excellent job of cleaning. Testing at WSU also indicated that this treatment tends to minimize adsorption losses of hydrocarbons stored in cans. Samples stored for several days have shown no significant shift in hydrocarbon content.

## 2. EMISSION RATE ALGORITHMS

Field data indicated changes in emission rates with temperature and light, although, other factors also seemed to significantly affect emission rates. These variables could include site specific variables such as soil fertility, plant moisture, weather, individual genetic variability, location of the sample on the tree, various pathologic conditions such as disease or injury and the age of the vegetation.

In order to more clearly estimate the effects of temperature and light on emission rates, a laboratory research program headed by Dr. D. T. Tingey, EPA Corvallis, was conducted utilizing specially designed environmentally controlled chambers. Whole plants were placed inside the chambers and the selected variable of plant temperature or light was changed while other conditions remained constant. The reports on experiments completed for Live Oak, an isoprene emitter, and for Slash Pine, a terpene emitter, indicated that there is a positive relationship between temperature and emission rates (Tingey, et al., 1978a,b). For terpene emissions no light dependency could be detected. Terpene emissions increased exponentially with temperature. The log of isoprene emissions varied with temperature and light according to a four parameter logistic function. However, light was saturating for isoprene emissions at fairly low intensities. The study quantified the relationships between leaf temperature and terpene emissions at any light level, between isoprene emissions and leaf temperature at various light levels and between isoprene emissions and light at various temperatures. Although the isoprene comparisons seem to be the same, laboratory results were different between the two sets of experiments. This variability could reflect the differing genetic backgrounds of the plants or the different pre-conditioning of the plants used in each experiment (Tingey, personal communication). In either case the data indicates the difficulty in trying to establish one emission rate algorithm to describe the variation of isoprene emissions with temperature and light.

## 2.1 RAW DATA CORRECTION FACTORS

The results of Tingey experiments were used to standardize field data to constant temperature and light conditions. No "average" emission rate algorithm which combined the results of the two isoprene experiments was available; therefore, for purposes of this emission inventory we have assumed that changes in isoprene emission rate with temperature for Live Oak would be similar to other isoprene emitters and have selected one of the emission rate algorithms for varying temperature at a light intensity of 800 $\mu E/m^2/sec$, (Tingey, et al., 1978a., Table 3). This algorithm was chosen because it indicated that additional increases in light intensity would not further increase isoprene emissions (i.e. isoprene emissions were saturated with respect to light). Additionally it was assumed that light intensity would be saturating for isoprene emissions from field samples during the daylight hours. We have also assumed that the change in non-methane hydrocarbon emission rates with temperature for all vegetation types (except for isoprene emissions) would be similar to Slash Pine (Tingey, et al., 1978b, Figure 4-a). Since the field data was collected over a range of temperatures a correction factor was used to standardize the hydrocarbon emissions to specified conditions of saturating light and a leaf temperature of 30°C. Figure 2.1-a shows the emission rate algorithms used to calculate the respective hydrocarbon emissions. The emission rate correction factors are equal to the result of the emission rate algorithm at 30°C divided by the result of the emission rate algorithm for the bag temperature of the field sample. This ratio is then multiplied times the field emission rate. Since the correction factors take the form of the ratio of the predicted emission rate at 30°C to the predicted emission rate at the sampling temperature, times the emission rate measured in the field, the units make no difference (note: the data in Tingey, 1978 a and b are in μg carbon). For nighttime all isoprene emissions were assumed to be zero. From energy balance calculations (Gates, 1971) it was apparent that leaf temperature and air temperature inside our enclosure during sampling were very close. The relationship between ambient air temperature, bag temperature and leaf temperature for some deciduous plants, was more difficult to estimate. The primary factors that affect this relationship are the size of the leaf, the energy absorption by the leaf, wind speed and transpiration rate (Gates, 1965). From our field measurements, it appeared that in the morning or afternoon hours or if the sunlight was filtered through foliage or shaded by clouds, bag temperatures were within 5°C of ambient air temperatures. If, however leaves were in direct sun at noon, bag temperatures and leaf temperatures could be up to 10°C warmer than ambient air temperatures.

Because bag temperature more accurately reflects leaf surface temperature, a probable controlling factor for emissions, the raw emission rates were specified in terms of bag temperature. When the emission rates based on bag temperature are standardized to an ambient temperature of 30°C,

## Figure 2.1-a. Emission rate algorithms

### Isoprene

$$^{+}\ln(Er) = \frac{4.88}{1 + \exp[-0.18\,(Ta - 25.26)]} + 0.11$$

Isoprene Temperature correction factor to 30°C:

$$Er = Er^{*}\left[\frac{34.194}{\exp \dfrac{4.88}{1 + \exp[-0.18\,(Ta - 25.26)]} + 0.11}\right]$$

where: $Er^{*}$ = Isoprene emission rate (measured)
$Er$ = Isoprene emission rate (std. to 30°C)
$Ta$ = Leaf temperature
34.195 = Predicted emission rate at 30°C
exp designates an exponent

### Terpenes

$$^{++}\quad Er = \exp[-0.332 + 0.0729\,(Ta)]$$

Terpene correction factor to 30°C:

$$Er = Er^{*}\ \frac{6.392}{\exp[-0.332 + 0.0729\,(Ta)]}$$

where: $Er^{*}$ = Terpene emission rate (measured)
$Er$ = Terpene emission rate (standardize to 30°C)
$Ta$ = Leaf temperature
6.392 = Predicted emission rate at 30°C
exp designates an exponent

[+] From Tingey *et al.*, 1978a.

[++] From Tingey *et al.*, 1978b.

there is a possibility of underestimating emission factors. For instance, the emission rate measured at a bag temperature of 35°C is necessarily lowered when standarized to a prevailing ambient condition of 30°C. Under these conditions leaf surface temperatures of unenclosed as well as the enclosed vegetation might be closer to the bag temperature than to the ambient air temperature (Gates, 1971). Therefore, when the emission rate is standarized to an ambient air temperature of 30°C, the effect is a lower emission estimate than would be expected at a corresponding leaf surface temperature of 35°C.

Although leaf temperatures may be higher than ambient temperatures for some leaves during some period of the day, it is much more difficult to estimate average diurnal leaf temperature cycles than average diurnal air temperature cycles. For this reason, in the Tampa/St. Petersburg natural emissions inventory WSU has assumed that bag temperatures equaled air temperature. It was recognized that this assumption could lead to underestimation of emission rates. This potential underestimation of emission estimates would be moderated somewhat for isoprene emitters because during periods of direct sunlight temperatures of some leaves may exceed 44°C and the leaf would then begin to physiologically shut down (Tingey, et. al., 1978a). Since isoprene emissions seem to be tied to photosynthesis (Sanadze and Kalandadze, 1966) the isoprene emission rate would be reduced for the over-heated leaves. In other words, in bright sun, leaf temperatures of some of the leaves for some broadleafed plants tend to be warmer than ambient air during some hours of the day, causing emission rates based only upon bag temperature and standardized to ambient air temperature to be too low. However, some of the leaves of a canopy may exceed a temperature of 44°C, causing a sharp decrease in isoprene emission rates. These factors, therefore, may tend to balance.

For purposes of modeling, emission rates are given for an average leaf temperature of 30°C during the daytime and 25°C at night. If emission estimates were desired for other duirnal temperature regimes, the emission algorithm correction factors could be used to adjust emission rates on an hourly basis.

Additionally, for this study it was assumed that the emission rate of an enclosed branch at a specific bag temperature would be representative of the emission rate of the whole plant if it were at the same temperature.

Samples which were collected using the bag collar were not corrected for temperature. These "flat samples" included some of the short row crops and all of the pasture (soil/leaf litter) and surface water samples. The temperature of the enclosure for these samples did not vary as greatly as for those samples using the Teflon bag enclosure. It was not known how leaf temperature, soil/water temperature or ambient air temperatures would affect the emission rates of these samples, and no experimental data was available to elucidate possible temperature relationships. Similarly, no attempt was made to standardize methane emission rates with temperature for any of the samples.

# 3. FIELD PROGRAM

Between the months of April and August 1977 a field sampling program was conducted to assess the hydrocarbon emission rates from biogenic sources in the Tampa/St. Petersburg study area. This section briefly discusses the selection of sampling sites. Appendix D lists the order of events for the field sampling program and discusses the typical sampling schedule.

## 3.1 Sampling Sites

Figure 3.1-a shows the boundaries of the study area. The area encompasses Hillsboro and Pinellis counties and includes the major cities of Tampa and St. Petersburg, Florida. Each dot on the map represents a site where emission samples were collected during the course of the April 1 to August 7, 1977 study.

As the map illustrates, the sampling sites are not evenly distributed over the study area. Sampling sites were limited by accessibility and by the number of vegetation associations (groupings of vegetation species which are normally found together) located in close proximity. Sampling sites were concentrated upon in locations which contained representative vegetation from most of the associations in the study area. These sites were sampled repeatedly over the study period. This was intended to help define the seasonal variability in emission rates. Although this data has not been statistically analysed for trends, in general, it appears that

# TAMPA / ST. PETERSBURG SAMPLING SITES

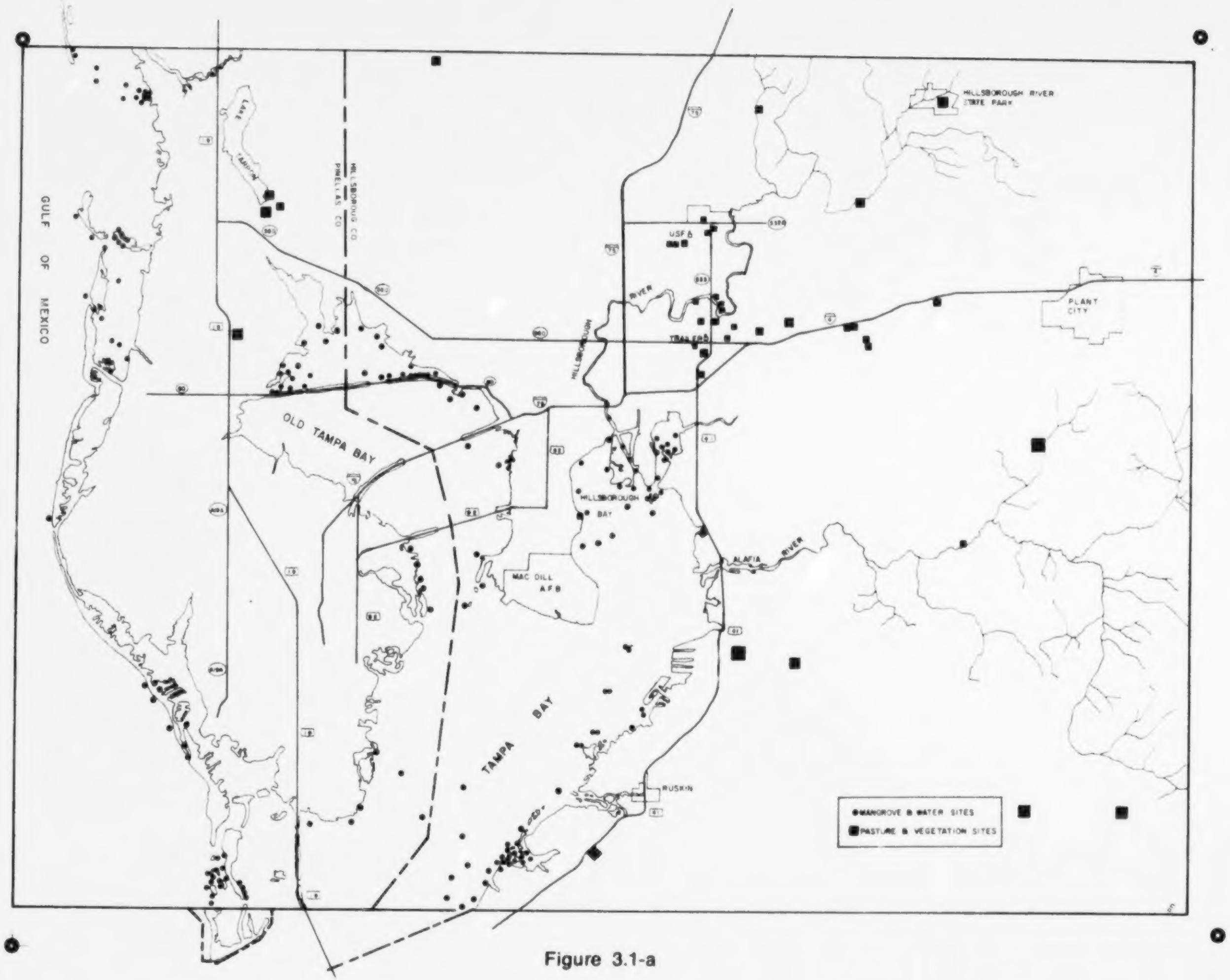

HILLSBOROUGH RIVER STATE PARK
PLANT CITY
USF
HILLSBOROUGH RIVER
HILLSBOROUGH CO
PINELLAS CO
LAKE TARPON
OLD TAMPA BAY
HILLSBOROUGH BAY
MAC DILL AFB
ALAFIA RIVER
TAMPA BAY
RUSKIN
GULF OF MEXICO
● MANGROVE & WATER SITES
■ PASTURE & VEGETATION SITES

Figure 3.1-a

sampling variability (the difference between similar samples) was greater than seasonal variability.

In order to get an idea of the variability of emission rates with location, we also collected a few samples at diverse sample sites throughout the study area. This sampling scheme allowed the collection of samples from many vegetation associations daily.

The decision for WSU to sample Row Crops was made in mid-June. Row Crops were therefore sampled in June and July after the first growing season and harvest had been completed. Emission rates from these plants therefore, might not be representative of active vegetation emissions during the growing season. Recent unpublished data by WSU for experiments which measured changes in vegetation emissions throughout a year indicate that vegetation emissions are probably highest for most plants during periods of active growth.

# 4. LEAF BIOMASS DISTRIBUTION AND QUANTITATION

As previously explained, the emission rates of the vegetation samples were measured in terms of emission/unit time/unit leaf biomass. In order to convert this emission rate into an area wide emission factor, (emission/ unit time/unit area) for each grid, it was necessary to conduct a detailed study to determine the type (plant species), quantity (biomass factors), and distribution (area coverage), of leaf biomass.

## 4.1 LEAF BIOMASS DISTRIBUTION

The study area primarily consisted of Hillsborough and Pinellis counties. In general, at the time that this study was conducted, Hillsborough county was mostly agricultural land closely intermixed with other vegetation communities. Many areas formerly in pine flatwoods had been converted to improved pasture with cypress heads and marshes intermixed. The pine flatwood areas remaining were located mainly in the southern half of the county or northwest of Tampa. Directly east of Tampa and five to ten miles east of Hillsborough Bay, pine and oak sandhills could be found. Wooded swamps occurred mainly in the Hillsborough River and Trout Creek drainage basins in floodplains and isolated depressions.

Nearly all of the southern half of Pinellis County was in developed land, primarily residential and urban. There was however a well-defined band of pine flatwoods running east-to-west, located south of Clearwater/Largo and North of St. Petersburg. Much of the residential land, particularly in older districts, was heavily covered in a mixture of natural and exotic trees and shrubs.

The portion of the county north of Old Tampa Bay was in pine flatwoods, sandhills, and agricultural land. Pine flatwoods were located near Sutherland Bayou and Smith Bayou. Xerophytic oak and pine were located to the east of the flatwoods area (Environmental Science and Engineering Inc., 1977).

The distribution of the vegetation types over the study area was determined primarily from Level II Land Use and Planning Maps. (Tampa Bay Regional Planning Council, 1977). These maps were developed by the U.S. Geological Survey for the Land Use and Land Cover data analysis system (LUDA), (Figure 4.1-a). The coordinates on the map in Figure 4.1-a which define the study area are: 315KmE., 3118KmN.; 396KmE., 3118KmN.; 315KmE., 3058KmN.; 396KmE., 3058KmN. The squares in the upper and lower left corners of the map designate the size of the study grids. The numbers in the grid squares represent the numbering system used to identify the location of each grid. As Figure 4.1-a shows, the coordinate system for the grids originates in the lower left-hand corner with 1-1. The first number designates the column of the grid and the second number designates its row. Therefore, the grids in column one are labeled (from bottom to top) 1-1, 1-2, 1-3 . . . 1-40 and those in row one are labeled (bottom right to left) 1-1, 2-1, 3-1 . . .54-1. Similarly the top row of grids would be labeled (right to left) 1-40, 2-40, 3-40 . . . 54-40. This makes a total of 2160 grids in the study area.

The original 1:250,000 scale Level II LUDA maps were designed to give resolution down to four hectares (10 acres) for categories of urban land, rivers, bays and estuaries and some agricultural land and 6 hectares (15 acres) for other land use categories (Anderson et al., 1976). Figure 4.1-b

TAMPA/ST. PETERSBURG LAND USE CATEGORIES

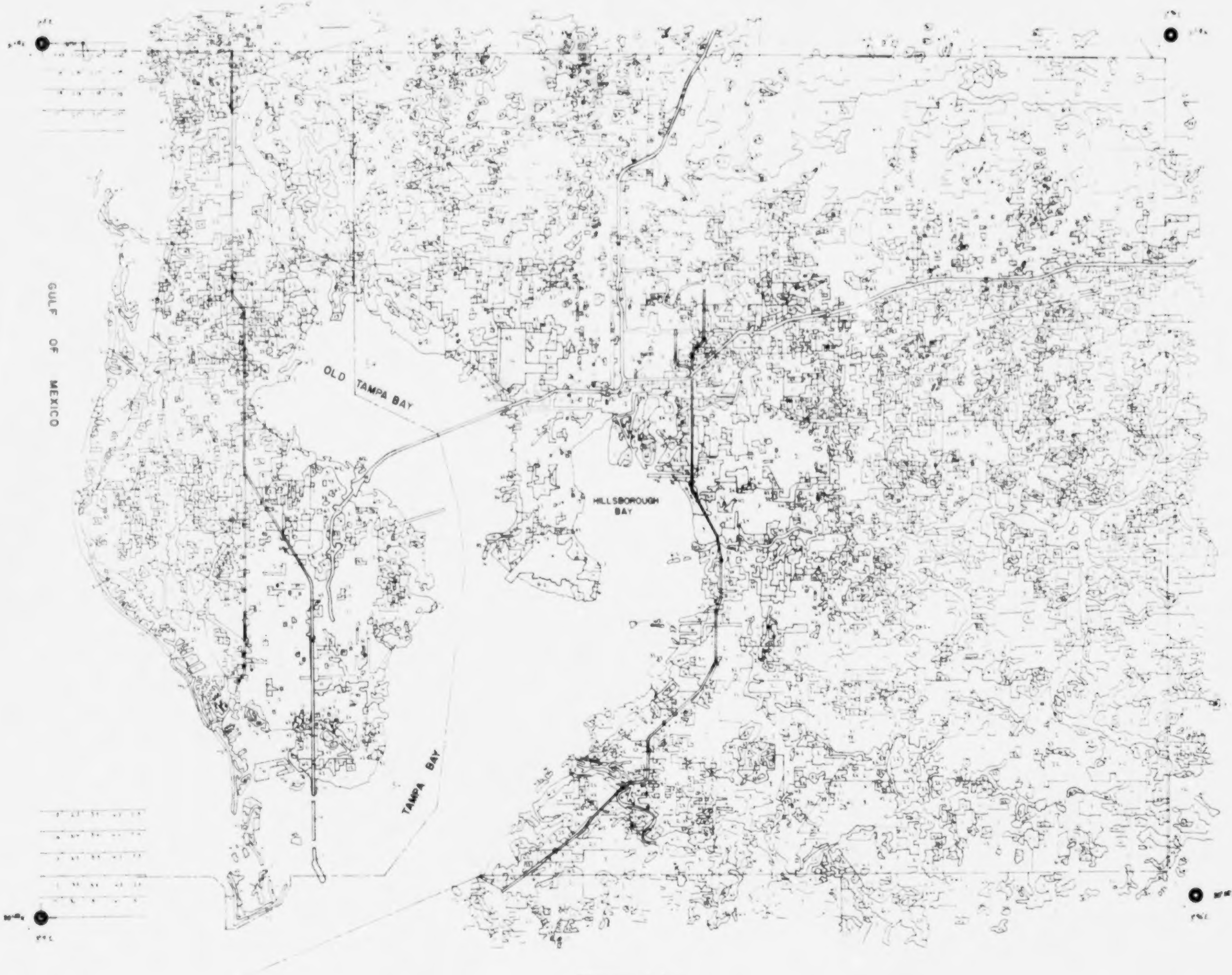

GULF OF MEXICO
OLD TAMPA BAY
HILLSBOROUGH BAY
TAMPA BAY

Figure 4.1-a

Figure 4.1-b Land Use map key

1. Urban or Built-up Land

11 Residential
12 Commerican and Services
13 Industrial
14 Transportation, Communincation, and Utilities
15 Industrial & Commercial Complexes
16 Mixed Urban or Built-up Land
17 Other Urban or Built-up Land

2. Agricultural Land

21 Cropland & Pasture
22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Hort. Areas
23 Confined Feeding Oper.
24 Other Agricultural Land
25 Cropland
26 Improved Pasture
27 Specialty farms
28 Horticultural farming

3. Rangeland

31 Herbaceous Rangeland
32 Shrub and Brush Rangeland
33 Mixed Rangeland

4. Forest Land

41 Deciduous Forest Land
42 Evergreen Forest Land
43 Mixed Forest Land
421 Planted Pine

5. Water

51 Streams and Canals
52 Lakes
53 Reservoirs
54 Bays and Estuaries
55 Gulf

6. Wetland

612 Forested Evergreen
61 Forested Wetland
621 Nonforested Wetland
6121 Mangroves

7. Barren land

71 Dry Salt Flats
72 Beaches
73 Sandy Areas other than Beaches
74 Bare Exposed Rock
75 Strip Mines, Quarries, and Gravel Pits
76 Transitional Areas
77 Mixed Barren land

8. Tundra

81 Shrub and Brush Tundra
82 Herbaceous Tundra
83 Bare Ground Tundra
84 Wet Tundra
85 Mixed Tundra

9. Perennial Snow or Ice

91 Perennial Snowfields
92 Glaciers

is a key for the numbers shown in Figure 4.1-a. Large LUDA maps are available from the Tampa Bay Planning Commission or from the State Capitol. The LUDA maps are based primarily upon land use or function in addition to ground cover. Therefore a two-hour flight by a doctoral candidate in Urban Ecology (and native of the Tampa area) in a small chartered airplane allowed for the confirmation of existing land use and stand composition information. The flight also enabled procurement of new information concerning the relationship of land use categories to vegetation types previously characterized by composition and biomass. Information from the flight was incorporated into the Land Use map shown in Figure 4.1-a.

To determine the distribution of vegetation by grid, a large LUDA Level II Map was overlaid with the grids of the study area. The percentage occupied by each land use category was then visually estimated for each grid. This technique was subjectively estimated to be accurate to within about five percent for each area in each grid. Visual area estimates compared within 6 percent of the values obtained from trial planimeter measurements of land use categories which occupied more than 20 percent of a grid. The planimeter (0.1mm resolution) WSU tested could not resolve areas smaller than 10 percent of a study grid from the 1:25,000 scale maps. WSU, therefore, chose the visual estimation technique due to its increased speed and accuracy over planimetry for these maps. The result was a set of LUDA categories and their percent area coverage for each grid of the study area. This information was then coded and stored on a computer tape.

## 4.2 LEAF BIOMASS QUANTITATION

This section contains a general discussion of leaf biomass quantitation. The section also contains a general description of the overall character and climate of the study area and a detailed discussion of each of the vegetation associations sampled during the course of the study. The typical species composition and the method used to estimate leaf biomass for each association has been outlined. Leaf biomass estimates were not made for the association categories of Improved Pasture, Unimproved Pasture, Tampa Bay and the Gulf of Mexico; Fresh Water Marsh or for some Row Crops. These categories were sampled using the bag collar, which enclosed 0.5m$^2$ of ground. The amount of vegetation enclosed was assumed to be representative of typical conditions.

Fortunately, leaf biomass tends to be convergent in forests of widely varying growth rates, dimensions, tree density per unit area, and species composition (Lieth and Whittaker, 1975). Assuming canopy closure, leaf biomass varies more with site index than with any of the other variables, (Satoo, 1971). The figures cited for central Florida vegetation bear that out, ranging from 200 g/m$^2$ to 700 g/m$^2$, with most of the vegetation types falling within the 450 to 650 range. (Lugo and Snedaker, 1974; Bayley, 1976; Mitsch, 1975; Carter et al., 1973; Wilbur, 1975).

While some sources describing broad regional trends indicate expected leaf biomass from 800 to 1200 g/m$^2$ in this latitude (Satoo, 1971) (Rodin and Bazilevich, 1965), the soils and rainfall regime of the region present limitations which result in edaphic climax vegetation. Nutrient poor, excessively drained soils, poorly drained soils and fire are the major causes of edaphic climax vegetation. This successional vegetation state is also less productive and lower in leaf biomass than the classic climatic climax vegetation type. Moreover, the study area is transitional with regard to climate. Where climax communities do occur there is a mixture of humid subtropical and humid sub-boreal vegetation types (Wunderlin, 1975; Pardue, 1971; Environmental Science and Engineering, Inc., 1977). While the Tampa Bay

Region is classified as an area of Humid Continental climate (Cfa in the Koppen-Geiger Classification) it is located at the southeastern extreme of the extent of this climate designation in North America (Koppen and Geiger, 1936). In addition to the north-south temperature and moisture gradients, the central portion of the Peninsula is characterized by marked gradients from each coast to the interior. This suggests that the vegetation of the region will not fit well within categories of vegetation typical of either subtropical or sub-boreal areas.

The vegetation in the study area had also been subjected to several forms of disturbance, ranging from clear-cutting to drainage, to severe prolonged drought. This disturbance and stress had caused many of the associations in this area to remain in an early to mid-successional level. Often the climax vegetation was also stressed. Because of these factors much of the vegetation was therefore somewhat impoverished and atypical with respect to other sub-tropical areas.

Several sources were consulted regarding the composition and leaf dry weight of trees and shrubs in each of the emission categories defined for purposes of the study. These are referenced in the leaf biomass tables in the discussion of each association. Wherever possible, local sources were consulted and given preference over more general information or over sources specific to other regions. In each case the full range of biomass figures is listed in the tables. The figure deemed most representative of the vegetation type as it occurred in the study area has been denoted by double underlines. Where species-specific or site-specific information was not available, the best approximation is cited. The final figures for each association are listed in Table 4.2-a.

Table 4.2-a SUMMARY OF LEAF BIOMASS FACTORS AND PLANT ASSOCIATION CROSS-REFERENCE LISTS

| Common Literature References | LUDA Land Use Categories | WSU Plant Associations | Leaf Biomass $g/m^2$ |
|---|---|---|---|
| Mangrove swamps | 6121 Mangroves | Mangroves | |
| | | Mature | 641.6 |
| | | Succession | 221.5 |
| Mixed hardwood swamps | forested wetlands | Oak-gum-cypress | |
| | | Dome | 331 |
| | | Drained | 203 |
| | | Undrained | 365.8 |
| Southern mixed hardwoods, Mixed hardwood swamps, Bayheads, Moist to mesic hardwood hammocks, Hydric hammock | 41 Deciduous forest,<br>612 Forested wetland evergreen | Hydric oak hammock | 614.8 |
| Sand hills | 42 Evergreen forest | Xeric oak hammock | 417 |
| Pine flatwoods | 42 Evergreen forest | Pines | 662.5 |
| -- | 31 Herbaceous rangeland<br>32 Shrub & brush rangeland | Palmetto | 450 |
| Oldfields with developing overstory | 11 Residential<br>32 Shrub & brush rangeland | Representitive shrubs | 200 |
| -- | 29 Citrus groves | Citrus groves | 658.3 |
| Improved pasture | 26 Pasture | Improved pasture | --- |
| Oldfields, early stage | 31 Herbaceous rangeland<br>32 Shrub & brush rangeland | Unimproved pasture | --- |
| -- | 25 Cropland | Row crops | |
| | | Tomatoes | 8.48 |
| | | Okra | 72.09 |

Although LUDA maps give some idea of the types of vegetation and its distribution in the study area, most leaf biomass references are given in terms of the vegetation associations shown in Table 4.2-b. The following section therefore gives a brief description, a detailed species composition list and the available leaf biomass figures for each vegetation association listed in the Table. Information used was obtained from a wide variety of sources, therefore it is not uniform with respect to detail or with respect to the method of leaf biomass determination.

### 4.2.1 Mangrove Swamps

Mangrove swamps occur in almost pure stands in the study area (Table 4.2.1-a). Red mangroves are the most common of the four species present and occupy the largest areas of the Tampa/St. Petersburg estuaries.

As illustrated by Table 4.2.1-b mangrove biomass is dependent upon the physiography of the area. Successional mangrove stands are considered to be less than five years old, and contain roughly one-third of the leaf biomass of mature stands. Therefore, two biomass factors were used in emission rate calculations. Where successional mangrove stands were identified, the lower biomass factor was used. In mature stands almost all of the leaf biomass is in the mangrove canopy.

Table 4.2.1-a MANGROVE SWAMP - COMMON SPECIES

| Species | Common Name |
|---|---|
| Overstory - | |
| *Avicennia germinans* | Black Mangrove |
| *Laguncularia racemosa* | White Mangrove |
| **Rhizophora mangle* | Red Mangrove |
| *Conocarpus erectus* | Buttonwood |

## Table 4.2.1-a MANGROVE SWAMP - COMMON SPECIES (continued)

| | |
|---|---|
| Understory - | |
| Saplings of overstory | |
| *Bacharix halimifolia* | Salt Myrtle |
| *Iva frutescens* | March Elder |
| *Borichia frutescens* | Sea Ox-eye |
| Ground cover - | |
| *Distichlis spicata* | Salt Grass |
| *Batis maritima* | Batis |

*dominant

## Table 4.2.1-b MANGROVE LEAF BIOMASS FACTORS

| Type of Association | Biomass of Sample Plots | Average Biomass |
|---|---|---|
| Overwash | 7263 kg/hectare<br>6946 kg/hectare | 641.6 $gm/m^2$ |
| Riverene | 3810 kg/hectare<br>9510 kg/hectare | |
| Fringe | 5934<br>5843 kg/hectare<br>7036 | |
| Island | 4990 kg/hectare | |
| Succession | 2215 kg/hectare | 221.5 $gm/m^2$ |

Reference: (Lugo and Snedaker, 1974)

### 4.2.2 Pine

The composition of this group is varied, however, the major portion of the biomass is dominated by one or two species. Often slash pine or longleaf pine occur in a closed canopy, thus limiting understory development.

Table 4.2.2-a lists the most common plant species found in the pine association. Table 4.2.2-b shows the range of needle biomass figures found for this plant association. The leaf biomass figure of 662.5 was selected because it came from the most local source and seemed to concur with the expected value based upon the climatology and physiography of the study area.

Table 4.2.2-a PINE - COMMON SPECIES

| Species | Common Name |
|---|---|
| Overstory - | |
| **Pinus elliottii* | Slash Pine |
| *Pinus palustris* | Longleaf Pine |
| *Pinus serotina* | Pond Pine |
| *Quercus minima* | Dwarf Oak |
| *Quercus laurifolia* | Laurel Oak |
| *Quercus nigra* | Water Oak |
| *Quercus pumila* | Runner Oak |
| *Quercus geminata* | Scrub-live-oak |
| Understory - | |
| **Serenoa repens* (5-25% coverage) | Saw Palmetto |
| *Myrtica cerifera* | Wax Myrtle |
| *Ilex cassine* | Dahoon holly |
| *Sambucus simponii* | Elderberry |
| *Seshenia punicea* | Seshenia |
| *Vaccinium arboreum* | Sparkleberry |
| *Viburnum rufiduluns* | Black Haw |
| *Lyonia Lucida* | Fetterbush |

*dominant

Table 4.2.2-a PINE - COMMON SPECIES (continued)

| Species | Common Name |
|---|---|
| Rhus copallina | Winged Sumac |
| Rubus spp. | Blackberry |
| Asimina spp. | Paw-paw |
| Ilex glabia | Gallberry |
| Gaylussacia dumosa | Dwarf Huckleberry |
| Vaccinium myrsinites | Ground blueberry |
| Hypericum spp. | St. John's Wort |
| Ascyrum tetia. | St. John's Wort |
| Lyonia ferraginca | Staggerbush |
| Myrica pulsilla | Dwarf Wax Myrtle |
| Pterocaulon undulatum | Rabbit Tobacco |

## Table 4.2.2-b PINE LEAF BIOMASS FACTORS

| Location/Type | Biomass | Source |
|---|---|---|
| N. Carolina<br>Loblolly Plantation | 480 g/m | (Bernier, 1975) |
| Duke 17 year Loblolly Plantation | 750 g/m$^2$ | (Arnts, *et al*, 1977) |
| Calhoun Experimental Forest/S. Carolina Loblolly Plantation | 700 g/m$^2$ | (Metz and Wells, 1965) |
| Several stands-several types/sub-boreal region | 500-550 g/m$^2$ | (Ovington, 1962) |
| Slash Pine Florida average | 662.5 g/m$^2$ | (Bayley, 1976) |
| Tampa/St. Petersburg | *662.5 g/m$^2$ | |

*Pine canopy only in plantations, or over-and-understory combined in natural stands of pine.

### 4.2.3 Citrus Trees

Good information is readily available for citrus groves due to their economic importance. The average leaf biomass of Florida citrus was calculated to be 658.3 g/m$^2$ (Bayley *et al.*, 1976). The regression developed for California citrus and Florida citrus used by Bayley to determine leaf biomass was:

$$1.426 \times \text{age}^{0.80948} \text{(where 0.80948 is an exponential)} = \text{leaf biomass in kg (Turrell, et al. 1969)}$$

Approximately 90% of the commercial citrus groves in the study area are planted in oranges. The remaining 10% and many abandoned groves are grapefruit. Orange groves in the study area were primarily the "Valencia" variety although some groves of the "Hamlin" variety did occur. All grapefruit groves found within the study area were "White Grapefruit." (personal communication with Dr. J. Allen, citrus experminent station, Lake Alfred, FLA).

### 4.2.4 Oak-Gum-Cypress

Table 4.2.4-a lists the plant species most common to the oak-gum-cypress association.

Biomass varies with site quality, particularly with the difference in cypress domes in standing water, and cypress stands in or along flowing water courses.

The oak-gum-cypress plant association has a relatively small leaf biomass. This can be explained in terms of nutrient limitations and drainage conditions and the physiological adaptations of this type of vegetation to such conditions; the conditions can best be described as constituting a physiological drought for the vegetation. This type of broad trend has been characterized by Bazilevich, *et al.*, (1970), for general forest types, for example:

| Total Plant Biomass, by Veg. Type | $g/m^2$ |
|---|---|
| Broadleaf forest on red and yellow soils | 45,000 |
| Broadleaf forest - swampy | 40,000 |
| Floodplain forest | 25,000 |
| Meadow - bog | 20,000 |

Thus lower biomass is expected in seasonally undated areas.

Cypress are deciduous, therefore a seasonal fluctuation of leaf biomass exists. The values reported here are March-October averages. The minimum leaf biomass occurs in January with 10 $g/m^2$. Leaf and twig fall occurs in October - November and new growth begins in March. The March through October understory average is approximately 40-50 $g/m^2$ (Odum and Ewel, 1976). Table 4.2.4-b summarizes the leaf biomass factors for the oak-gum-cypress association.

Table 4.2.4-a OAK-GUM-CYPRESS - COMMON SPECIES

| | |
|---|---|
| Overstory - | |
| *Taxodium distichum* (vav. nutans) | Pond Cypress |
| *Nyssa biflora* | Swamp Tupelo |
| *Taxodium distichum* | Bald Cypress |
| *Fraxinus caroliniana* | Walter Ash |
| *Acer rubrum* | Southern Red Maple |
| *Nyssa sylvatica* | Black Gum |
| *Liquidumbar styraciflua* | Sweetgum |
| *Quercus nigra* | Water Oak |
| *Sabal palmetto* | Sabal Palmetto |
| *Carpinus caroliniana* | Blue Beech |
| *Ilex cassine* | Dahoon Holly |
| *Juniperus silicicola* | Southern Red Cedar |
| Understory - | |
| *Myrica cerifera* | Wax Myrtle |
| *Cephalanthus occidentalis* | Buttonbush |
| *Tyoria Lucida* | Fetterbush |
| *Salix virginiana* | Virginia Willow |
| *Ludwigia peruviana* | Primrose Willow |
| *Similax laurifolia* | Bamboo Briar |
| *Rhus toxicodendron* | Poison Ivy |
| *Itea virginica* | Sweet-spires |

Table 4.2.4-a OAK-GUM-CYPRESS - COMMON SPECIES (continued)

Groundcover -

| | |
|---|---|
| *Polygonum punctatum* | Smartweed |
| *Lachnanthus caroliniana* | Redroot |
| *Saururus cernuus* | Lizard's tail |
| *Rubus spp.* | Blackberry |
| *Woodwardia virginica* | Virginia Chain fern |
| *Osmunda cinnamonmea* | Cinnamon Fern |
| *Osmunda regalis* | Royal Fern |
| *Sphagnum spp.* | Sphagnum Moss |

Table 4.2.4-b OAK-GUM-CYPRESS LEAF BIOMASS FACTORS ($g/m^2$)

| Location/Type | Overstory | Understory | Total |
|---|---|---|---|
| [1]Withlacooche Fla/Dome | Cypress (121),<br>Tupelo gum (160)<br>= 281 | 50 | 331 |
| [2]Fahkahatchee Strand, Fla/drained | Cypress (8167.6)<br>Total x*0.02 = 163 | 40 | 203 |
| [2]Fahkahatchee Strand, Fla/undrained | Cypress (19,790.3 $g/m^2$)<br>Total x 0.02 = 315.8 $g/m^2$ | 50 | 365.8 |

[1] Mitsch, 1975

[2] Carter, *et al.*, 1973 and Mitsch, 1975

*0.02 is equal to the portion of the total biomass which is present as leaves (Leith, 1975).

### 4.2.5 Xeric Oak Hammock

The predominance of evergreen vegetation in this association (i.e. xeric evergreen oaks) is attributable to a mineral retention adaptation by the plants. The relatively low biomass reflects the impoverishment due to excessively drained sandy soils.

Table 4.2.5-a lists the most common vegetation of this association. Table 4.2.5-b shows the range of biomass estimates available for this association. A leaf biomass factor 417 $g/m^2$ is most appropriate for the study area since it represents the most local source of information.

Table 4.2.5-a COMMON XERIC OAK HAMMOCK SPECIES

| Species | Common Name |
|---|---|
| Overstory - | |
| *Quercus laevis | Turkey Oak |
| *Quercus virginiana | Live Oak |
| *Pinus elliottii | Slash Pine |
| *Pinus palustris | Longleaf Pine |
| Quercus geminata | Scrub-live-oak |
| Quercus falcata | Southern Red Oak |
| Quercus laurifolia | Laurel Oak |
| Quercus incana | Bluejack Oak |
| Quercus myrtifolia | Myrtle Oak |
| Pinus clausa | Sand Pine |
| Understory - | |
| *Diospyros ebenaster | Persimmon |
| *Myrtica cerifera | Wax Myrtle |
| *Serenoa repens | Saw Palmetto<br>(5-25% coverage) |

*dominant

## Table 4.2.5-a COMMON XERIC OAK HAMMOCK SPECIES (continued)

Saplings of overstory species especially:

| | |
|---|---|
| *Quercus myrtifolia* | Myrtle Oak |
| *Quercus geminata* | Scrub Oak |
| *Bumelia sp.* | Buckthorn |
| *Lyonia ferruginea* | Staggerbush |
| *Lyonia lucida* | Fetterbush |

Groundcover -

| | |
|---|---|
| *Aristida Stricta* | Wiregrass |
| *Andropogon spp.* | |
| *Polygala grandiflora* | Beard Grasses |
| *Asclepias spp.* | Milkweeds |
| *Berlandiera subacaulis* | Green Eyes |
| *Opuntia spp.* | Prickly Pear |
| *Sporobolus junceus* | Pinewoods Dropseed |
| *Chrysabalanus oblongifolius* | Gopher Apple |
| *Heterotheca graminifolia* | Grassy-leaf Golden Aster |
| *Sorghastrum secudatum* | Lopsided Indiangrass |

## Table 4.2.5-b XERIC OAK HAMMOCK LEAF BIOMASS FACTORS

| Location | Type | Leaf Biomass | Source |
|---|---|---|---|
| North Florida | Upland Oak | 417 g/m$^2$ | (Odum, Brown, 1973) |
| Brookhaven N.Y. | 45 yr. old Oak-Pine | 443 g/m$^2$ | (Whittaker and Woodwell, 1969) |
| Cove Forest Great Smokey Mtns. | Mixed | 351 g/m$^2$ | (Spurr, Barnes, 1973) |

Best Estimate: 417 g/m$^2$ including understory

## 4.2.6 Hydric Oak Hammock

The most common species present in this association are listed in Table 4.2.6-a. Specific Biomass data for the dominant species is also included.

Leaf biomass factors for the Hydric Oak Hammock were calculated using the mean tree method and the data from Table 12.

The mean tree method (Lieth and Whittaker, 1975) involves averaging the basal area of all the trees in this association and fitting the means to a regression line of leaf biomass and the diameter at breast height (DBH)to yield average leaf biomass per tree. This is then multiplied by the tree density in terms of trees per unit area to result in the leaf biomass factor per unit area. For this vegetation type it was assumed that approximately 10% of the leaf biomass occurred in the understory. Therefore, the leaf biomass factor per unit area for the Hydric Oak Hammock plant association is approximately 615 $g/m^2$ (Figure 4.2.6-a).

Table 4.2.6-a COMMON HYDRIC OAK HAMMOCK SPECIES

Dominant Overstory Species (Wilbur 1975, Carter *et al.*, 1973)

| Species | Common Name | Relative Dominance (%) | Basal Area ft /acre | Density (trees per acre) |
|---|---|---|---|---|
| *Quercus laurifolia* | Laurel Oak | 57.19 | 82.18 | 103.99 |
| *Acer rubrum* | Red Maple | 14.10 | 20.25 | 75.23 |
| *Nyssa biflora* | Swamp Tupelo | 8.11 | 11.65 | 50.89 |
| *Pinus elliotii* | Slash Pine | 11.66 | 16.75 | 15.49 |
| *Magnolia virginiana* | Sweetbay | 2.71 | 3.89 | 11.06 |
| *Liquidumbar styraciflua* | Sweetgum | 0.99 | 1.42 | 11.06 |
| *Ilex coriacea* | Large Gallberry | 0.76 | 1.09 | 11.06 |

## Table 4.2.6-a (cont.) COMMON HYDRIC OAK HAMMOCK SPECIES

Dominant Overstory Species (Wilbur 1975, Carter *et al.*, 1973)

| Species | Common Name | Relative Dominance (%) | Basal Area ft /acre | Density (per acre) |
|---|---|---|---|---|
| *Fraxinus pennsylvanica* | Green Ash | 0.54 | 0.77 | 11.06 |
| *Ulmus americana* | American Elm | 2.33 | 3.35 | 6.64 |
| *Carya aquatica* | Water Hickory | 0.53 | 0.75 | 6.64 |
| *Fraxinus caroliniana* | Carolina Ash | 0.41 | 0.58 | 6.64 |
| | Dominant Understory Species | | | |
| *Vaccinium arboreum* | Tree Sparkleberry | 0.34 | 0.49 | 2.21 |
| *Salix caroliniana* | Carolina Willow | 0.19 | 0.28 | 2.21 |
| *Myrica cerifera* | Southern Waxmyrtle | 0.09 | 0.12 | 2.21 |
| *Ilex myrtifolia* | Myrtle | 0.09 | 0.12 | 2.21 |

Common Overstory Species

| Species | Common Name |
|---|---|
| *Quercus virginiana* | Live Oak |
| *Taxodium distichum* | Bald Cypress |
| *Sabal palmetto* | Cabbage Palm |
| *Quercus nigra* | Water Oak |
| *Persia borbonica* | Red Bay |
| *Gordonia lasianthus* | Loblolly Bay |
| *Juniperus silicicola* | Southern Red Cedar |
| *Carpinus caroliniana* | Blue Beech |
| *Cornus stricta* | Stiffcornel Dogwood |
| *Ilex coriacea* | Sweet Gallberry |
| *Ilex cassine* | Dahoon Holly |

Table 4.2.6-a (cont.) COMMON HYDRIC OAK HAMMOCK SPECIES

| | |
|---|---|
| Common Understory Species | |
| *Cephalanthus occ* | Button Bush |
| *Lyonia lucida* | Fetterbush |
| *Rhus toxicodendron* | Poison Ivy |
| *Similax Spp*. | Greenbriar |
| *Decumaiia barbara* | Climbing Hydrangea |
| *Itea virginica* | Sweet-spires |
| *Rhus copallina* | Winged Sumac |
| *Ilex myrtifolia* | Myrtle-leaved Holly |
| Common Ground Cover | |
| *Saururus cernuus* | Lizard's Tail |
| *Polygonum punctatum* | Smartweed |
| *Hydrocotyle spp*. | Pennywort |
| *Dyschoriste humistrate* | Dyschoriste |
| *Panicum spp*. | Panicgrass |
| *Carex spp*. | Sedges |
| *Woodwardia areolata* | Neeted Chain Fern |
| *Osmunda cinnamonea* | Cinnamon Fern |
| *Osmunda regalis* | Royal Fern |

Figure 4.2.6-a

Hydric oak hammock mean tree method of leaf biomass determination

The leaf biomass of an average tree is equal to the regression of the average diameter at breast height (DBH) on the average basal area (Auerbach, 1971, Pool, *et al.*, 1974).

1. Average basal area equals:

$$\frac{\text{Total basal area}}{\text{Total number of trees}} = \frac{143.69}{318.61} = \underline{0.45\ \text{ft}^2}$$

2. Average diameter at breast height equals: $\frac{\text{Basal area} \times 4}{3.14}$ (Leith and Whittaker, 1975):

$$= \frac{0.45\ \text{ft}^2 \times 4}{3.14} = 0.75\ \text{ft} = 22{,}860\ \text{cm DBH}$$

3. Leaf biomass per tree is estimated from the corrected regression lines of DBH on dry leaf weight developed by Auerbach and Nelson (1975).

Average leaf biomass = 8kg/tree

4. If there are an average of 318.61 trees per acre (Table 4.2.6-a) then the total overstory leaf biomass equals:

$$8000\text{g/tree} \times 318.61\ \text{trees/acre} \times 2.171 \times 10^{-4}\ \text{acre/m}^2 = \underline{553.3\ \text{g/m}^2}$$

5. Assuming roughly 10% of the total leaf biomass is understory then the total association figure equals:

$$553.3\ \text{g/m}^2\ \text{overstory} + 61.5\ \text{g/m}^2\ \text{understory} = \underline{\underline{614.8\ \text{g/m}^2}}$$

### 4.2.7 Representative Shrubs

The shrub species listed in Table 4.2.7-a are typical of disturbed and early successional vegetation. Shrubs which occur as understory vegetation for other plant associations are included in the appropriate association discription. Biomass estimates are shown in Table 4.2.7-a. The total leaf biomass of this association is estimated at 200 g/m$^2$. Approximately 90% of the leaf biomass of this vegetation type is included in overstory. (Carter *et al.*, 1973)

Table 4.2.7-a COMMON SPECIES OF REPRESENTATIVE SHRUB

| Species | Common Name |
|---|---|
| Overstory - sparse small in stature | |
| *Quercus virginiana* | Live Oak |
| *Prunus serotina* | Black Cherry |
| *Pinus elliottii* | Slash Pine |
| *Pinus palustris* | Longleaf Pine |
| Understory - | |
| *Prunus serotina* | Black Cherry |
| *Diospyros virginiana* | Persimmon |
| *Myrtica cerifera* | Wax Myrtle |
| *Salix caroliniana* | Willow |
| *Aster carolinianus* | Aster |
| Ground Cover - | |
| *Eupatorium capillifolium* | Dog Fennel |
| *Eupatorium compositifolium* | |
| *Solidago microcephala* | Goldenrod |
| *Sesbania exaltata* | Sesbania |
| *Andropogon ssp.* | Beardgrasses |
| *Paspalum notatum* | Bahia Grass |
| *Panicum spp.* | Panic Grasses |
| *Bidens pilosa* | Beggars Tick |

Table 4.2.7-b LEAF BIOMASS OF REPRESENTATIVE SHRUBS

Baseline data compiled by Carter, et al., 1973*

| Species | Avg. Diameter | Avg. Ht. | Avg. Leaf Biomass |
|---|---|---|---|
| Myrica cerifera<br>(Wax Myrtle) | 4.6cm | 3.0m | 405g |
| Salix caroliniana**<br>(carolina willow) | 7.9cm | 7.4m | 490g |

* Field observation in the study area indicates an approximate ground coverage of 2 sq meters for wax myrtle of 5 cm DBH, and 3 square meters for willow trees/shrubs of 8 cm DBH. The understory and ground cover biomass are an additional 11%.

Thus the leaf biomass per unit area is: 200 g/m$^2$ for wax myrtle and 160 g/m$^2$ (willow). The average is 180 g/m$^2$. If understory and ground cover vegetation are added to this the total leaf biomass is approximately 200 g/m$^2$.

**Representative sample tree, not average of all trees sampled; many samples obtained during and after leaf fall.

### 4.2.8 Palmetto

This vegetation type is early successional and appears in areas recently disturbed by clearing or burning. Two types of Palmetto are common to the study area: Saw palmetto Serenoa repens and Cabbage palm Sabal palmetto. Sabal palmetto is considered to be common in the overstory of the Hydric oak hammock, and is not discussed here. Saw palmetto is by far the most common species and occupies almost pure stands in disturbed areas. Overstory and understory species are relatively insignificant to this classification.

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Since Saw Palmetto is of questionable economic value, not much information concerning leaf biomass is available. The leaf biomass of Palmetto can be estimated from the range of biomass of the associations in which Saw Palmetto occurs. The range of biomass for Palmetto was estimated by WSU to be probably between that of pine flatwoods (663 g/m$^2$) and successional shrubs (200 g/m$^2$). Based upon this range and upon measurements of Palmetto leaf biomass made during field sampling, a value of 450 g/m$^2$ was estimated to be representative of the study area.

### 4.2.9 Pasture

For the categories of unimproved pasture, improved pasture and the marine samples the area enclosed was used directly in the calculation of the emission factors as discussed in Section 1.1.

Species lists for improved and unimproved pasture are shown in Table 4.2.9-a.

Table 4.2.9-a PASTURE

| Species | Common Name |
|---|---|
| Overstory - sparse | |
| *Quercus virginiana* | Live Oak |
| *Pinus palustrus* | Longleaf Pine |
| *Pinus elliottii* | Slash Pine |
| Understory - | |
| Unimproved Pasture | |
| *Eupatorium capillifolium* | Dog Fennel |
| *Eupatorium compositifolium* | Dog Fennel |
| *Solidago microcephala* | Goldenrod |
| *Andropogon spp.* | Beardgrasses |

Table 4.2.9-a PASTURE (continued)

| *Species* | *Common Name* |
|---|---|
| Unimproved Pasture | |
| *Paspalum notatum* | Bahia grass |
| *Panicum spp.* | Panic grass |
| *Bidens pilosa* | Beggars tick |
| *Sestania exaltata* | Sestania |
| Improved Pasture | |
| Groundcover - | |
| *Paspalum notatum* | Bahia grass |
| *Cynodon dactylon* | Bermuda grass |
| *Digitaria sanguinalis* | Crabgrass |
| *Axonopus affinis* | Carpetgrass |
| *Trifolium spp.* | Clover |
| *Spobolus poirettii* | Smutgrass |

### 4.2.10 Row Crops

Row crops in the Tampa/St. Petersburg study area include tomatoes, strawberries, beans, squash, okra, melons, peppers, cucumbers and cabbage (Florida Agricultural Statistics, 1977).

Crop yields often average 30,000 lbs./acre for tomatoes, the major row crop, and 8,000 lbs./acre for okra. High yields can be attained even in these sandy leached soils, with the application of large amounts of fertilizer. Two crops per year are often attained. The primary growing seasons are March-July and October-January, although cold-weather crops such as cabbage may be growing all year. All categories of row crops which were sampled, except okra and tomatoes, used the same sample collecting procedure as for pasture samples. For each tomato and okra sample, one entire plant was enclosed. The plant emissions were sampled and then the plant was clipped and the leaves were separated and dried. Leaf biomass factors were obtained by multiplying the average planting density (plants/m$^2$) by the average of the dry leaf weights of the plants sampled. Therefore, for tomatoes this is equal to: 1.73 plants/m$^2$ x 4.9g dry wt leaves/plant = 8.48g/m$^2$. For okra the leaf biomass factor is: 8.9 plants/m$^2$ x 8.1g dry wt leaves = 72.09g/m$^2$. This comparatively low leaf biomass accounts for a small part of the productivity. If for example the crop yield is added, the fruit plus leaf biomass becomes:

Tomato

3,000 lbs. fruit/acre = 3363g/m$^2$ x 0.10g dry wt/g wet wt. = 1634.3
leaves = 8.48
total g/m$^2$ = 1643

Okra

8,000 lbs. fruit/acre = 4360g/m$^2$ x 0.25g dry wt/g wet wt. = 1090 g/m$^2$
leaves = 72.09
1162 g/m$^2$

The total biomass figures are comparable with productivity values for Wisconsin hay and corn yields and are somewhat higher than the 600-920 g/m$^2$ reported for row crops in Tennessee (Lieth and Whittaker, 1975).

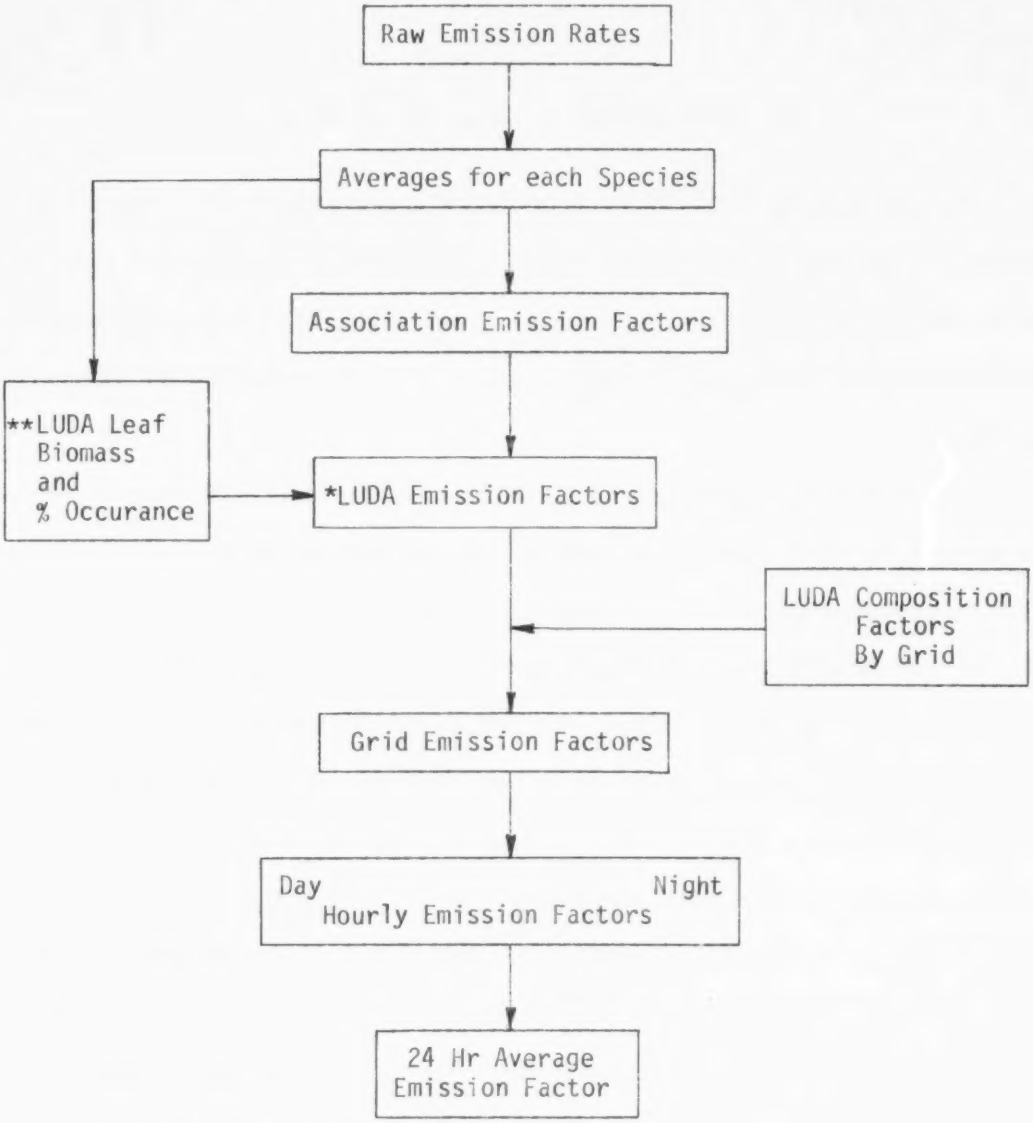
Conversion factors from yield to g/m$^2$ dry weight for okra and tomatoes were obtained from Dr. D. Bienz, Professor of Horticulture at WSU. All other information concerning crops, plant spacing, growing season and yields was obtained from Dr. J. Montelaro, Professor and Extension Vegetable Specialist, Vegetable Crops Department, University of Florida at Gainesville.

## 5. DEVELOPMENT OF EMISSION INVENTORY

The previous sections have described the background work which was necessary in order to develop a detailed estimate of natural hydrocarbon emissions for the Tampa/St. Petersburg area. The following section will describe the collation of the basic sets of information into an emission estimate.

Figure 5-a is a generalized schematic outline of the methodology used to develop an inventory of the natural hydrocarbon emissions by grid. Basically it involves calculating average emission rates for each vegetation species and sample type collected during the field study. These average emission rates are then grouped into vegetation associations. The vegetation associations are multiplied by their leaf biomass factors and grouped into land use categories compatible with the LUDA map designations. In addition, LUDA categories may contain certain species/sample types that do not occur in associations. For example, ornamental shrubs like oleander occur in the residential LUDA category but in none of the associations. Some of these additional species' emissions are measured in terms of μg/g leaf biomass/hour (eg. oleander). These are then converted to $\mu g/m^2/hr$. These LUDA emission factors are then multiplied times the percent composition of each LUDA category in each grid. The individual grid emissions can then be totaled for day and night emissions to get a daily emission rate (24 hrs). Figure 5-b is a detailed schematic of the procedures used to arrive at hourly emission

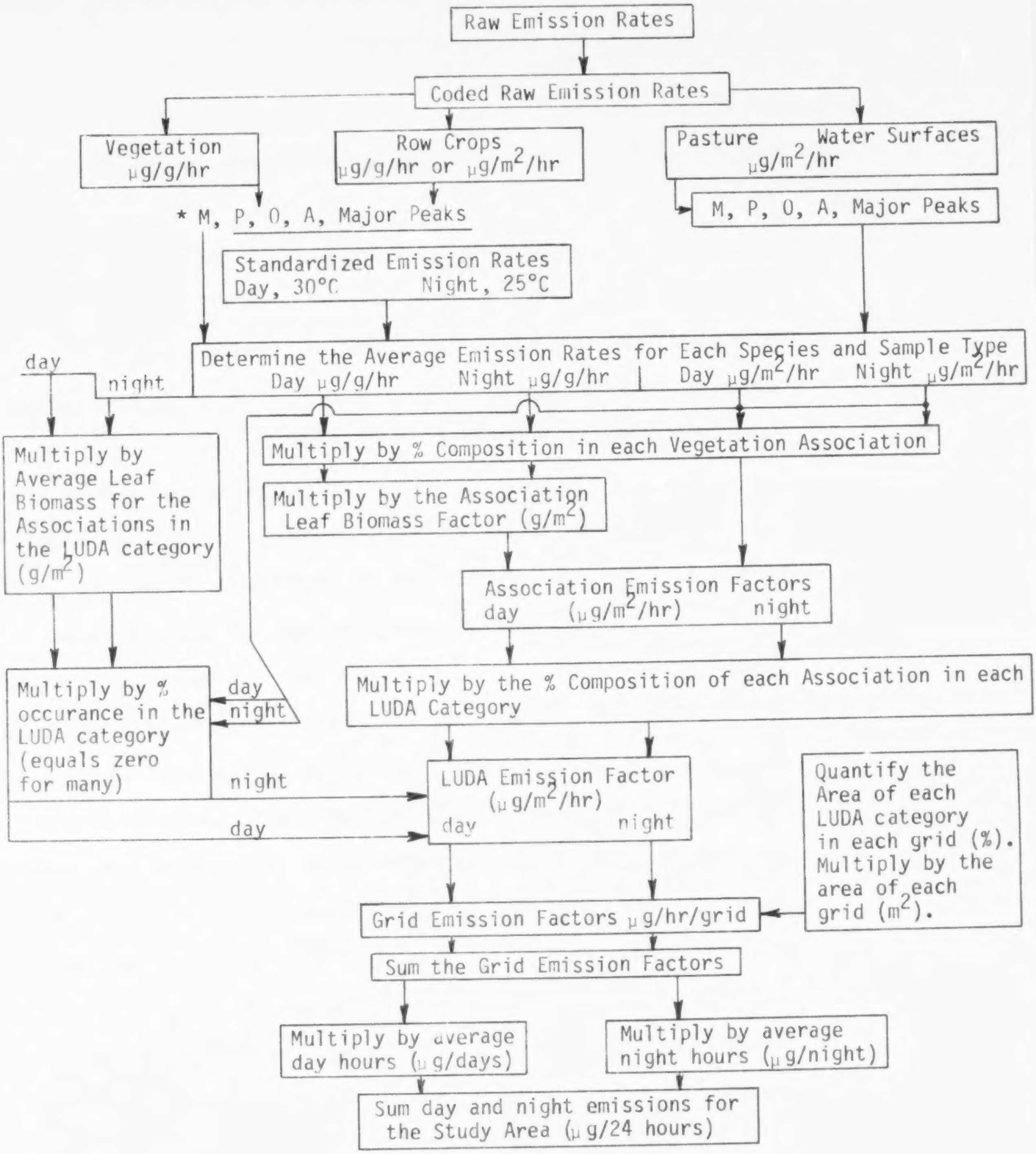
Figure 5-a. Simplified Schematic of Natural Emission Inventory Proceedure for the Tampa/St. Petersburg Study Area.


Raw Emission Rates
Averages for each Species
Association Emission Factors
**LUDA Leaf Biomass and % Occurance
*LUDA Emission Factors
LUDA Composition Factors By Grid
Grid Emission Factors
Day
Night
Hourly Emission Factors
24 Hr Average Emission Factor

*LUDA = Land Use and Land Cover Data Analysis System

**This route was used only for species which occurred in LUDA Category, but were not present in any Association (see text).

Figure 5-b. Detailed Schematic of Proceedure Used to Compile Tampa/ St. Petersburg Natural Hydrocarbon Emission Inventory.


Raw Emission Rates
Coded Raw Emission Rates
Vegetation μg/g/hr
Row Crops μg/g/hr or μg/m²/hr
Pasture Water Surfaces μg/m²/hr
* M, P, O, A, Major Peaks
M, P, O, A, Major Peaks
Standardized Emission Rates Day, 30°C Night, 25°C
Determine the Average Emission Rates for Each Species and Sample Type
Day μg/g/hr Night μg/g/hr Day μg/m²/hr Night μg/m²/hr
day
night
Multiply by Average Leaf Biomass for the Associations in the LUDA category (g/m²)
Multiply by % Composition in each Vegetation Association
Multiply by the Association Leaf Biomass Factor (g/m²)
Association Emission Factors day (μg/m²/hr) night
Multiply by % occurance in the LUDA category (equals zero for many)
day
night
Multiply by the % Composition of each Association in each LUDA Category
night
LUDA Emission Factor (μg/m²/hr) day night
day
Quantify the Area of each LUDA category in each grid (%). Multiply by the area of each grid (m²).
Grid Emission Factors μg/hr/grid
Sum the Grid Emission Factors
Multiply by average day hours (μg/days)
Multiply by average night hours (μg/night)
Sum day and night emissions for the Study Area (μg/24 hours)

*M=methane, P=Parafins, O=Oefins, and A=Aromatics.

factors by grid and summary emission factors for the entire study area from the raw emission rates. The following section describes the elements which are illustrated in each step of this schematic.

## 5.1 SUMMARY OF AVAILABLE DATA

We have discussed the following elements of the emission inventory data:

1. Field sampling program. The program was conducted between April and August 1977. Emission rates were measured for various species during all types of weather which occurred during the study period. Repetitive diurnal samples were collected twice for species representative of each vegetation association. Samples were analyzed within 24 hours of collection. Emission rates were quantified in terms of methane(M), paraffins(P), olefins(O), aromatics(A), total nonmethane hydrocarbons(TNMHC) and for each major hydrocarbon peak.
2. Emission rate algorithms. It was known that all emissions were responsive to temperature and that only isoprene emissions seemed sensitive to light. Algorithms generated in the EPA-Corvallis laboratory for Slash Pine and for Live Oak were used to standardize field data. It was assumed that all nonmethane non-isoprene emission rates for vegetation would be similar to slash pine emission algorithms, that all isoprene emission rates would be similar to one of the Live Oak isoprene emission algorithms and that light was saturating for isoprene emissions in the daytime.
3. The determination of the distribution and quantitation of leaf biomass. This part of the study was based upon land use and land

cover maps, personal observations in the study area, extensive search of the available literature and limited field measurements. The leaf biomass factors were estimated for each of the vegetation associations in the study area. Land use definitions were used to estimate the distribution of associations and species within LUDA categories. LUDA maps were used to estimate the distribution and types of leaf biomass in each grid.

From the above data a detailed natural emission inventory for each grid in the study area was constructed using the following steps.

## 5.2 STEP 1: CODING OF RAW EMISSION RATES

The variables which were recorded during the collection of each sample and which were thought to be important in describing and predicting differences in emission rates were stored on a Washington State University computer tape along with the raw emission rate data for each sample. This was done so that relationships between emission rates and sample variables might become clearer. The raw emission rate data is stored in the following format:

1. Columns 1-3 contain the sample number. Numbers range from 001 to 631.
2. Columns 4-6 contain the vegetation species or vegetation category. Numbers range from 001 thru 950. The first digit corresponds to the broad vegetation type of the sample. The second digit corresponds to the genus of the sample in that type, and the third digit represents the species. For example, 001 and 011 are both mangrove however, they are separate genera and species. Numbers 101 and 102 represent two species of pines. Table 5.1-a lists the species codes and the sample types to which they correspond.

## Table 5.1-a VEGETATION SPECIES/SAMPLE CATEGORY CODES

| | |
|---|---|
| 001 | Black Mangrove |
| 011 | White Mangrove |
| 021 | Red Mangrove |
| 101 | Slash Pine |
| 102 | Longleaf Pine |
| 103 | Sand Pine |
| 104 | Southern Red Pine |
| 601 | Australian Pine |
| 201 | Laurel Oak |
| 202 | Water Oak |
| 203 | Turkey Oak |
| 204 | Live Oak |
| 205 | Southern Red Oak |
| 206 | Bluejack Oak |
| 207 | Myrtle Oak |
| 208 | Willow Oak |
| 301 | Saw Palmetto |
| 311 | Sabal Palmetto |
| 401 | Wax Myrtle |
| 411 | Elderberry |
| 421 | Dwarf Huckleberry |
| 431 | Groundsel Bush |
| 441 | Persimmon |
| 451 | Dahoon Holly |
| 461 | Red Bay |
| 471 | Red Mulberry |
| 481 | Sweet Acacia |
| 491 | Viburnum |
| 492 | Oleander |
| 501 | Oranges |
| 511 | Grapefruit |
| 111 | Pond Cypress |
| 112 | Bald Cypress |
| 611 | Sweetgum |
| 621 | American Elm |
| 631 | Carolina Ash |
| 641 | Willow |
| 651 | Red Maple |
| 671 | Hickory |
| 700 | Mixed grasses |
| 701 | Bahia |
| 711 | Bermuda |
| 721 | Clover |
| 731 | Pensicola |
| 741 | Sawgrass |
| 801 | Tomatoes |
| 811 | Strawberries |
| 821 | Beans |
| 831 | Watermellon |
| 841 | Okra |
| 901 | Grass mudflat (marine) 0"-2" water |
| 902 | Grass mudflat (2"-12") |
| 903 | Grass mudflat (12"-2') |
| 904 | Grass mudflat (2'-5') |
| 905 | Sandy Bottom (>5') |
| 911 | Decaying marine algae |
| 912 | Decaying maring grass |
| 913 | Decaying mixed veg. |
| 921 | Mudflat no grass exposed 0"-2" |
| 922 | Mudflat (2"-12") |
| 923 | Mudflat (12"-2') |
| 924 | Mudflat (2'-5') |
| 925 | Mudflat (>5') |
| 931 | Sandy Beach |
| 941 | Fresh water marsh (0"-2") |
| 942 | Fresh water marsh (>12") |
| 943 | Fresh water marsh Hyacinth |
| 944 | Fresh water marsh Waterlilly |
| 950 | Oyster Beds |

3. Columns 7-10 contain the location of the sample within the study grid. The digits correspond to the grid coordinates.
4. Column 11 is a one-digit code which defines the person who collected the sample. This was done so that any trends in data related to sampling technique could be noted. 1 = Don Stearns, 2 = Phil Sweany, 3 = Pat Zimmerman.
5. Columns 12-16 represent the date in the format; Month, Day, Day, Year, Year.
6. Columns 17-18 represent the time at which the sample was collected in hours from 01-24.
7. Columns 19-21 contain the number of the canister in which the sample was collected from 001-999. This was recorded so that any anomalous emission rate trends corresponding to a specific sample container could be determined.
8. Column 22 contains a subjective estimation of the sunlight conditions where 0 is dark, 1 is dusk or overcast, 2 is partly cloudy or shady, 3 is filtered sunlight or early morning or late afternoon sunlight, and 4 is the direct noonday sunlight.
9. Column 23 contains a subjective estimation of the illumination of the enclosed branch or "bag sunlight" using the same scale as item 8.

10. Column 24 describes the rain, cloud, and moisture conditions during the time of collection of the sample:

| Code | Cloud Cover | Soil | Leaves |
|---|---|---|---|
| 0 | <50% | dry | dry |
| 1 | <50% | dry | wet |
| 2 | <50% | damp | dry |
| 3 | <50% | wet | wet |
| 4 | Raining during sample | | |
| 5 | >50% | dry | dry |
| 6 | >50% | dry | wet |
| 7 | >50% | damp | dry |
| 8 | >50% | damp | dry |
| 9 | >50% | Raining during sample | |

11. Columns 25 and 26 describe the wind conditions during the collection of the sample:

| Column 25 | | Column 26 | |
|---|---|---|---|
| Code | Direction | Code | Direction |
| 0 | N | 0 | calm |
| 1 | E | 1 | 0-7 mph |
| 2 | S | 2 | 7-15 |
| 4 | W | 3 | 10-20 |
| 5 | NE | 4 | 20-30 |
| 6 | NW | 5 | 30-40 |
| 7 | SE | 6 | 40-50 |
| 8 | SW | 7 | Too windy for good sample |
| 9 | calm/variable | | |

12. Column number 27 contains a code from 0-9 which is a subjective evaluation of the health of the plant being sampled:

| Code | Age | Health |
|---|---|---|
| 0 | dead | --- |
| 1 | mature | stagnant |
| 2 | medium | poor |
| 3 | medium | good |
| 4 | young | poor |
| 5 | young | good |
| 6 | sapling | poor |
| 7 | sapling | good |
| 8&9 | does not apply (refers to "flat samples") | |

13. Columns 28 and 29 contain the temperature of the ambient air at the time that the sample was collected in °C.

14. Columns 30-31 contain the temperature of the air in the enclosure at the end of the sample period in °C.

15. Columns 32 and 33 are blank.

16. Column 34 contains a letter code from a to z which describes the time between the collection of the sample and its analysis:

| Code | Time |
|---|---|
| a | <2 hours |
| b-t | 2-20 hours |
| u-y | 2-6 days |
| z | >7 days |

17. The total length of time that the vegetation sampled was enclosed is coded in column 35:

| Code | Time (minutes) | Code | Time | Code | Time |
|---|---|---|---|---|---|
| A | 10 | I | 18 | R | 27 |
| B | 11 | J | 19 | S | 28 |
| C | 12 | K | 20 | T | 29 |
| D | 13 | L | 21 | U | 30 |
| E | 14 | M | 22 | V | 31 |

| Code | Time (minutes) | Code | Time | Code | Time |
|---|---|---|---|---|---|
| F | 15 | N | 23 | W | 32 |
| G | 16 | O | 24 | X | 33 |
| H | 17 | P | 25 | Y | 34 |
| | | Q | 26 | Z | 35 |

18. Column 36 is a subjective evaluation of reliability of the emission rate results where zero is least reliable and 9 is most reliable. This number was assigned by allocating a possible six points to quantitation of the analytical results and three points to collection of the sample. Caution must be exercised when attempting to interpret reliability factors, for if one of the components is low and the other is high, the reliability could appear to be "average" when in fact, it would be very low. Samples which were obviously contaminated or invalid due to sampling or analytical difficulties have been deleted.

19-27 Columns 37-80 contain the coded emission rates for the various components of the sample. The emission rate values are four digit numbers where the first three digits represent the value and the fourth digit represents the position of the decimal point. For example, a value of 2342 would be equal to an emission rate of 23.4. Negative emission rates sometimes occurred for some components of some species. Negative emission rates imply that an uptake occurs. Negative emission rates occur when the amount of hydrocarbons in the background sample ($C_{sb}$ X Ve) is greater than the amount of hydrocarbons in the emission rate sample ($C_{ss}$ (Zv + Ve)). If the dead volume (Ve) is overestimated an apparently negative emission rate can occur. This could easily happen for sweet gums in which very high background values sometimes occur.

However, in most cases the negative values appear to be representative of actual conditions. For negative emission rates the minus sign is considered as a first digit for placement of the decimal. Therefore, values of -202 and -200 would equal -2.0 and -.020 respectively. The identities of the emission rate components are as follows:

| Item# | Column | Description |
|---|---|---|
| 19 | 37-40 | Methane |
| 20 | 41-44 | Total non-methane hydrocarbons |
| 21 | 45-48 | Paraffins |
| 22 | 49-52 | Olefins |
| 23 | 53-56 | Aromatics |
| 24 | 57-62 | *Major Peak No. 1 |
| 25 | 63-68 | Major Peak No. 2 |
| 26 | 69-74 | Major Peak No. 3 |
| 27 | 75-80 | Major Peak No. 4 |

*The "major peaks" may not be present for all samples.

The emission rate of each major peak is preceded by a two character code which identifies the peak as follows:

| Code | Identity | Code | Identity |
|---|---|---|---|
| 1. DL | d-Limonene | 14. 17 | unknown 17 |
| 2. AP | $\alpha$-Pinene | 15. 18 | unknown 18 |
| 3. 3C | $\Delta^3$-Carene | 16. 20 | unknown 20 |
| 4. BP | $\beta$-Pinene | 17. 21 | unknown 21 |
| 5. 9A | unknown 29-A | 18. 22 | unknown 22 |
| 6. 6A | unknown 26-A | 19. 23 | unknown 23 |
| 7. 1A | unknown 21-A | 20. 24 | unknown 24 |
| 8. MY | Myrcene | 21. 25 | unknown 25 |
| 9. TP | Terpinolene | 22. 26 | unknown 26 |
| 10. OA | unknown 10-A | 23. 27 | unknown 27 |
| 11. UT | unknown terpenes | 24. 28 | unknown 28 |
| 12. IS | Isoprene | 25. 29 | unknown 29 |
| 13. 16 | unknown 16 | | |

## 5.3 STEP 2: DETERMINATION OF SPECIES EMISSION RATES

Since no change in non-isoprene emission rates with light intensity were apparent from the field data or the Tingey, et al., 1978b report, All raw nonmethane, non-isoprene emission rates for all vegetation samples (except some row crops), including those collected during the daytime and during the nighttime vegetation were standardized to 30°C for day and 25°C for night. All of the non-methane emission rates of isoprene emitters which were sampled during the daylight were standardized to 30°C for day. WSU's diurnal samples of isoprene emitters and Tingey et al., 1978a indicate that no isoprene is emitted in the dark. However, all of the other non-methane non-isoprene emissions from the isoprene emitters were standardized to day and to night.

Because of this scheme, emission samples were used in the day and in the night averages for all non-isoprene emissions. Therefore, the summation of N (number of samples used in each average) for all of the species in Appendix A will result in roughly twice the number of samples that were actually collected. Flat samples were not corrected for temperature. The emission rates of each species/emission category was then averaged (Appendix A). The variability of the average species emission rates in Appendix A is expressed as a Standard Deviation Error of the Mean(SD).

## 5.4 STEP 3: DETERMINATION OF ASSOCIATION EMISSION FACTORS

The estimated species/sample type composition for each association, as determined in Section 4, is shown in Table 5.4-a. Wherever each association occurred in the study area it was assumed to consist of the same species in the same proportions. The name of the association is shown in the first column followed by the code letter used to designate it on the computer tape. The "species code" column lists the species sample/type included in each association as defined in Table 5.1-a. The "multiplication factor" column

Table 5.4-a ASSOCIATION SPECIES/SAMPLE TYPE COMPOSITION FACTORS FOR TAMPA/ST. PETERSBURG, FLORIDA

| ASSOCIATION | ASSN CODE | SPECIES CODE | MULTI FACTOR | WSU ASSN | ASSN CODE | SPECIES CODE | MULTI FACTOR |
|---|---|---|---|---|---|---|---|
| Mangrove | A | 001 | 32.11 | Drained Stand | E | 112 | 121.88 |
| | | 011 | 96.11 | | | 651 | 20.30 |
| | | 021 | 512.88 | | | 202 | 20.30 |
| | | 901 | 0.10 | | | 611 | 20.30 |
| | | 902 | 0.40 | | | 311 | 12.18 |
| | | 922 | 0.40 | | | 451 | 8.12 |
| | | 923 | 0.10 | | | 401 | 8.12 |
| | | | | | | 641 | 12.18 |
| | | | | | | 941 | 0.10 |
| | | | | | | 741 | 0.90 |
| Pine | B | 101 | 331.25 | Undrained Stand | F | 112 | 256.06 |
| | | 102 | 198.75 | | | 651 | 18.29 |
| | | 201 | 66.25 | | | 202 | 21.95 |
| | | 301 | 33.13 | | | 611 | 18.29 |
| | | 491 | 33.13 | | | 311 | 14.63 |
| | | 700 | 1.00 | | | 451 | 7.32 |
| | | | | | | 401 | 7.32 |
| | | | | | | 641 | 21.95 |
| | | | | | | 941 | 0.20 |
| | | | | | | 942 | 0.20 |
| | | | | | | 741 | 0.60 |
| Citrus | C | 501 | 592.47 | Xeric Oak | G | 203 | 125.10 |
| | | 511 | 65.83 | | | 204 | 137.61 |
| | | 711 | 0.25 | | | 101 | 58.38 |
| | | 721 | 0.25 | | | 102 | 41.70 |
| | | 731 | 0.25 | | | 201 | 8.34 |
| | | 700 | 0.25 | | | 206 | 8.34 |
| | | | | | | 207 | 8.34 |
| | | | | | | 103 | 8.34 |
| | | | | | | 441 | 8.34 |
| | | | | | | 401 | 8.34 |
| | | | | | | 301 | 4.17 |
| | | | | | | 700 | 1.00 |
| Oak-Gum-Cypress Domes | D | 112 | 198.6 | | | | |
| | | 651 | 16.55 | | | | |
| | | 202 | 33.10 | | | | |
| | | 611 | 33.10 | | | | |
| | | 311 | 16.55 | | | | |
| | | 451 | 6.62 | | | | |
| | | 401 | 6.62 | | | | |
| | | 641 | 19.86 | | | | |
| | | 941 | 0.10 | | | | |
| | | 741 | 0.90 | | | | |

Table 5.4-a ASSOCIATION SPECIES/SAMPLE TYPE COMPOSITION FACTORS FOR TAMPA/ST. PETERSBURG, FLORIDA (continued)

| WSU ASSN | ASSN CODE | SPECIES CODE | MULTI FACTOR |
|---|---|---|---|
| Hydric Oak | H | 201 | 325.84 |
| | | 651 | 98.37 |
| | | 101 | 73.78 |
| | | 611 | 30.74 |
| | | 621 | 12.30 |
| | | 671 | 12.30 |
| | | 631 | 12.30 |
| | | 401 | 6.15 |
| | | 112 | 6.15 |
| | | 311 | 6.15 |
| | | 204 | 6.15 |
| | | 202 | 6.15 |
| | | 461 | 6.15 |
| | | 451 | 6.15 |
| | | 700 | 0.70 |
| | | 741 | 0.30 |
| Represent-ative Shrub | I | 204 | 10 |
| | | 101 | 6 |
| | | 102 | 4 |
| | | 401 | 51 |
| | | 641 | 46 |
| | | 441 | 51 |
| | | 411 | 10 |
| | | 421 | 10 |
| | | 451 | 4 |
| | | 461 | 4 |
| | | 491 | 4 |
| | | 701 | 0.30 |
| | | 790 | 0.70 |
| Palmetto | J | 301 | 450 |
| | | 700 | 1.0 |
| Improved Pasture | K | 700 | 0.20 |
| | | 701 | 0.10 |
| | | 711 | 0.10 |
| | | 721 | 0.10 |
| | | 731 | 0.45 |
| | | 741 | 0.05 |
| Unimproved Pasture | L | 700 | 0.45 |
| | | 701 | 0.10 |
| | | 711 | 0.10 |
| | | 721 | 0.05 |
| | | 731 | 0.10 |
| | | 741 | 0.20 |
| Crops | M | 801 | 4.24 |
| | | 811 | 0.10 |
| | | 821 | 0.35 |
| | | 841 | 3.60 |

lists emission multiplication factors determined by multiplying the association leaf biomass shown in Table 4.2-a times the estimated percent composition by species. Where identical species were not sampled, substitutions of species which were sampled and which were believed to have similar emission rates were made. For flat categories (surface water, pastures, etc.) the multiplication factor represents the percent of the ground in the association covered by the specific "flat sample" type. Therefore, each association contains leaf biomass factors multiplied by relative occurrance for canopy vegetation and percent ground cover factors for flat sample categories. Therefore, for each association, overstory, understory and soil/litter emissions are accounted for. The multiplication factors were then multiplied times the average emission rates for each respective species/sample type in Appendix A and the products were summed to give an emission factor ($\mu g/m^2/hr$) for each association. Since each sample emission rate consisted of TNMHC, M, P, O, A and major peaks for day and for night a computer was used to manipulate the data.

Appendix B lists the association emission rates and the variance ($S^2$) for each. The standard deviation is equal to the square root of the variance. The variance was chosen because it is easier to manipulate statistically for later use in estimating the overall variability of the final emission estimate. The association variance was calculated with the assumption that all samples were independent.

## 5.5 Step 4: DEVELOPMENT OF LUDA EMISSION ESTIMATES

Since the most detailed spatial characterization of the vegetation in the study area was based upon land use and land cover categories, it was necessary to estimate the composition of land use categories in terms of the vegetation associations and species present. Some vegetation species sampled (notably ornamentals) which were not normally included in association categories, were present in LUDA categories (such as the "residential" category). Therefore, the development of LUDA categories includes the emission rates of associations weighted by their relative percent ground cover, plus emission rates of individual vegetation species. Since species emission rates are in μg/g/hr, to convert to μg/m$^2$/hr emission factors the species emission rates were multiplied by the average leaf biomass of the LUDA category. This was determined from the average leaf biomass of each association in the LUDA category multiplied by its relative occurrance. The determination of association and species contributions to each LUDA category were based upon the definition of each LUDA category (Anderson, et al., 1976), association species composition (Section 4), and upon direct field observation in the study area.

Table 5.5-a outlines the information which was used for computer development of LUDA emission rates. The "map no." column refers to the numbers used to designate each LUDA category on the LUDA map (Figure 4.1-a). The column marked "ASSN Multiplication Factor" is derived from the percentage of each association in the LUDA category (1.00=100%) or the multiplication factor for individual species. As can be seen from Table 5.5-a, the LUDA category for "residential" does not add up to 100 percent. This is because this LUDA category includes species as well as associations. Therefore, for species whose emission rates were measured in μg/g/hr, the association multiplication factor is equal to the average species emission rate multiplied by the average LUDA leaf biomass times the relative percent occurrance. Other categories which do not add up to 1.00 (100%) include LUDA#52 "Lakes." In this case

## Table 5.5-a EMISSION FACTORS FOR TAMPA/ST. PETERSBURG LUDA CATEGORIES

| Map # | LUDA Category | ASSN CODE | WSU ASSN | SPECIES CODE | ASSN Multi. Factor |
|---|---|---|---|---|---|
| 11 | Residential | B | Pine | X | 0.08 |
| | | G | Xeric Oak | X | 0.08 |
| | | I | Shrubs | X | 0.02 |
| | | *X | X | 701 | 0.40 |
| | | X | X | 481 | 14.04 |
| | | X | X | 491 | 14.04 |
| | | X | X | 492 | 17.55 |
| | | X | X | 601 | 17.55 |
| | | X | X | 471 | 7.02 |
| | | X | X | 431 | 7.02 |
| 21 | Cropland Pasture | M | Cropland | X | 0.50 |
| | | L | Unimproved Pasture | X | 0.50 |
| 22 | Orchards Nurseries Vineyards Misc. | SAME AS RESIDENTIAL | | | |
| 24 | Agriculture Land | M | Cropland | X | 0.50 |
| | | K | Imp. Pasture | X | 0.45 |
| | | L | Unimp. Pasture | X | 0.05 |
| 25 | Cropland | M | Crops | X | 1.00 |
| 26 | Pasture | K | Imp. Pasture | X | 0.85 |
| | | F | Cypress Domes | X | 0.10 |
| | | B | Pine | X | 0.05 |
| 27 | Specialty Farms | X | X | 912 | 1.00 |
| 28 | Horticulture Farms | SAME AS RESIDENTIAL | | | |
| 29 | Groves | C | Citrus | X | 1.00 |

* X means "not applicable"

Table 5.5-a EMISSION FACTORS FOR TAMPA/ST. PETERSBURG LUDA CATEGORIES (continued)

| Map # | LUDA Category | WSU ASSN CODE | WSU ASSN | SPECIES CODE | ASSN Multi. Factor |
|---|---|---|---|---|---|
| 31 | Herbaceous | J | Palmetto | X | 0.10 |
| | Rangeland | B | Pine | X | 0.10 |
| | | D | Cypress | X | .04 |
| | | E | Cypress | X | .03 |
| | | F | Cypress | X | .03 |
| | | L | Unimp. Pasture | X | 0.70 |
| 32 | Shrubs | J | Palmetto | X | 0.10 |
| | Brush | I | Shrubs | X | 0.20 |
| | Rangeland | L | Unimp. Pasture | X | 0.70 |
| 33 | Mixed | J | Palmetto | X | 0.08 |
| | Rangeland | B | Pine | X | 0.07 |
| | | D | Cypress | X | 0.03 |
| | | E | Cypress | X | 0.02 |
| | | F | Cypress | X | 0.02 |
| | | I | Shrubs | X | 0.08 |
| | | L | Unimp. Pasture | X | 0.70 |
| 41 | Deciduous | G | Xeric Oak | X | 0.08 |
| | Forest | H | Hydric Oak | X | 0.20 |
| 42 | Evergreen | B | Pines | X | 0.60 |
| | Forest | G | Xeric Oak | X | 0.40 |
| 421 | Planted | X | X | 101 | 596.25 |
| | Pine | X | X | 102 | 66.25 |
| 43 | Mixed Forest | Average 41 and 42 | | | |
| 51 | Streams | X | X | 941 | 0.10 |
| | Canals | X | X | 942 | 0.90 |
| | | X | X | 943 | 0.40 |
| | | X | X | 944 | 0.10 |

Table 5.5-a EMISSION FACTORS FOR TAMPA/ST. PETERSBURG LUDA CATEGORIES (continued)

| Map # | LUDA Category | WSU ASSN CODE | WSU ASSN | SPECIES CODE | ASSN Multi. Factor |
|---|---|---|---|---|---|
| 52 | Lakes | X | X | 941 | 0.10 |
| | | X | X | 942 | 0.90 |
| | | X | X | 943 | 0.20 |
| | | X | X | 944 | 0.10 |
| 53 | Reservoirs | X | X | 941 | 0.10 |
| | | X | X | 942 | 0.90 |
| | | X | X | 943 | 0.20 |
| | | X | X | 944 | 0.10 |
| 54 | Bays Estuaries | X | X | 901 | 0.07 |
| | | X | X | 902 | 0.13 |
| | | X | X | 903 | 0.20 |
| | | X | X | 904 | 0.10 |
| | | X | X | 921 | 0.05 |
| | | X | X | 922 | 0.05 |
| | | X | X | 923 | 0.10 |
| | | X | X | 924 | 0.20 |
| | | X | X | 925 | 0.10 |
| | | X | X | 911 | 0.05 |
| | | X | X | 912 | 0.20 |
| | | X | X | 913 | 0.10 |
| | | X | X | 950 | 0.20 |
| 55 | Gulf of Mexico | X | X | 901 | 0.05 |
| | | X | X | 902 | 0.15 |
| | | X | X | 903 | 0.20 |
| | | X | X | 904 | 0.10 |
| | | X | X | 905 | 0.20 |
| | | X | X | 921 | 0.02 |
| | | X | X | 922 | 0.03 |
| | | X | X | 923 | 0.15 |
| | | X | X | 924 | 0.05 |
| | | X | X | 925 | 0.05 |
| | | X | X | 911 | 0.05 |
| | | X | X | 912 | 0.10 |
| | | X | X | 193 | 0.05 |
| | | X | X | 950 | 0.10 |

Table 5.5-a EMISSION FACTORS FOR TAMPA/ST. PETERSBURG LUDA CATEGORIES (continued)

| Map # | LUDA Category | WSU ASSN CODE | WSU ASSN | SPECIES CODE | ASSN Multi. Factor |
|---|---|---|---|---|---|
| 61 | Deciduous Forested Wetland | D | Cypress Dome | X | 1.00 |
| 612 | Forested Evergreen Wetland | D | Cypress | X | 0.30 |
| | | E | Cypress | | 0.20 |
| | | F | Cypress | | 0.50 |
| 6121 | Mangroves | A | Mangroves | X | 1.00 |
| 621 | Non Forested Wetland | X | X | 741 | 0.10 |
| | | X | X | 941 | 0.10 |
| | | X | X | 942 | 0.90 |
| | | X | X | 943 | 0.40 |
| | | X | X | 944 | 0.10 |
| 71 | Dry Salt Flats | | | 931 | 1.00 |
| 72 | Beaches | X | X | 913 | 0.07 |
| | | | | 911 | 0.07 |
| | | | | 912 | 0.07 |
| 73 | Sandy Non Beaches | X | X | 931 | 1.00 |
| 74 | Barren Rock | -- | -- | -- | 0 |
| 75 | Strip Mines | X | X | 931 | 1.00 |
| 76 | Transitional Barren Land | X | X | 931 | 1.00 |
| 77 | Mixed Barren Land | X | X | 931 | 1.00 |

100% of the lake is covered with water (Species sample type codes 941 and 942). Additionally, approximately 30% of the surfaces of lakes were estimated to be covered by aquatic plants (ES&ET, 1974). Appendix C lists the emision rates and their variances for each LUDA category.

## 5.6 STEP 5 DETERMINATION OF GRID EMISSION RATES FOR THE STUDY AREA

Land use categories for each grid in the study area were estimated from a LUDA map, as previously described. The grid number and its associated LUDA composition in % grid area were then coded into the computer. Next, for each grid, the emission rates for each LUDA category ($\mu g/m^2/hr$) were multiplied by their percent occurrance in the grid and by the area of the grid ($m^2$) for day and for night. The results were hourly emission rates for each grid for daytime at a temperature of 30°C and for nighttime at a temperature of 25°C. These hourly emission rates were then used to prepare daily emission density maps for the study area. To prepare the maps each day (24 hours) was assumed to consist of 12 hours of the daytime emission rate plus 12 hours of the nighttime emission rate for each grid.

The emission densities of each grid for methane, TNMHC, paraffins, olefins and aromatics were then plotted separately on an x-y coordinate system by computer with the aid of Symmap, a packaged data presentation (Dudnik, 1971). Figures 5.6-a through 5.6-e illustrate the emission density maps. It should be noted that separate ranges were selected for methane emissions and TNMHC emissions. Emission ranges for paraffins, olefins and aromatics are identical to facilitate emission density comparisons. The maps clearly illustrate that the primary biogenic emissions are olefins and that these tend to occur in forested regions. It can be seen that grid emission densities are fairly low with a maximum TNMHC emission of approximately 88 $mg/m^2$/day (24 hours). This is equivalent to an average flux of 3,667 $\mu g/m^2/hr$.

TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY

TOTAL NONMETHANE HYDROCARBON (TNMHC)

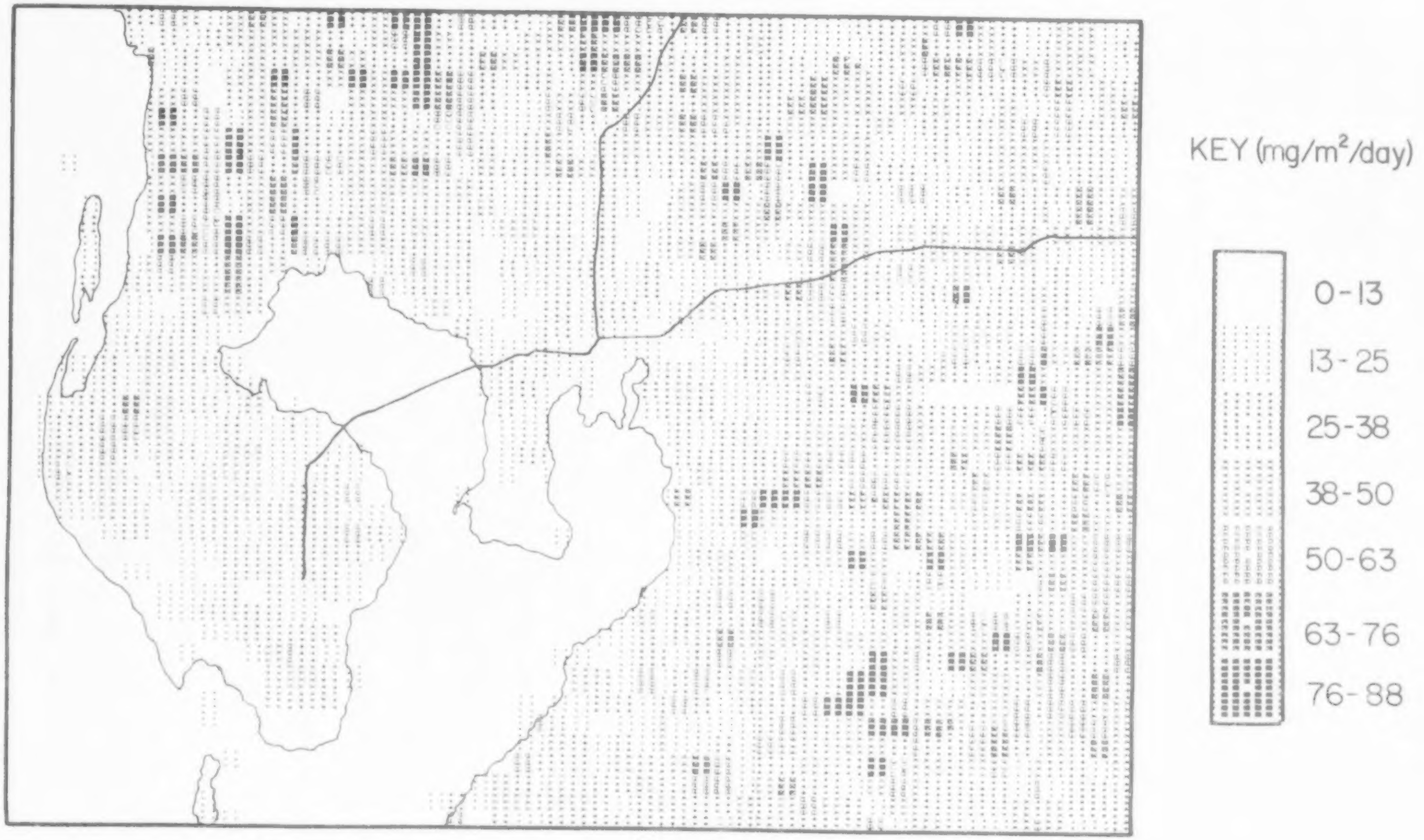

KEY (mg/m²/day)
0-13
13-25
25-38
38-50
50-63
63-76
76-88

Figure 5.6-a

## TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY

## METHANE

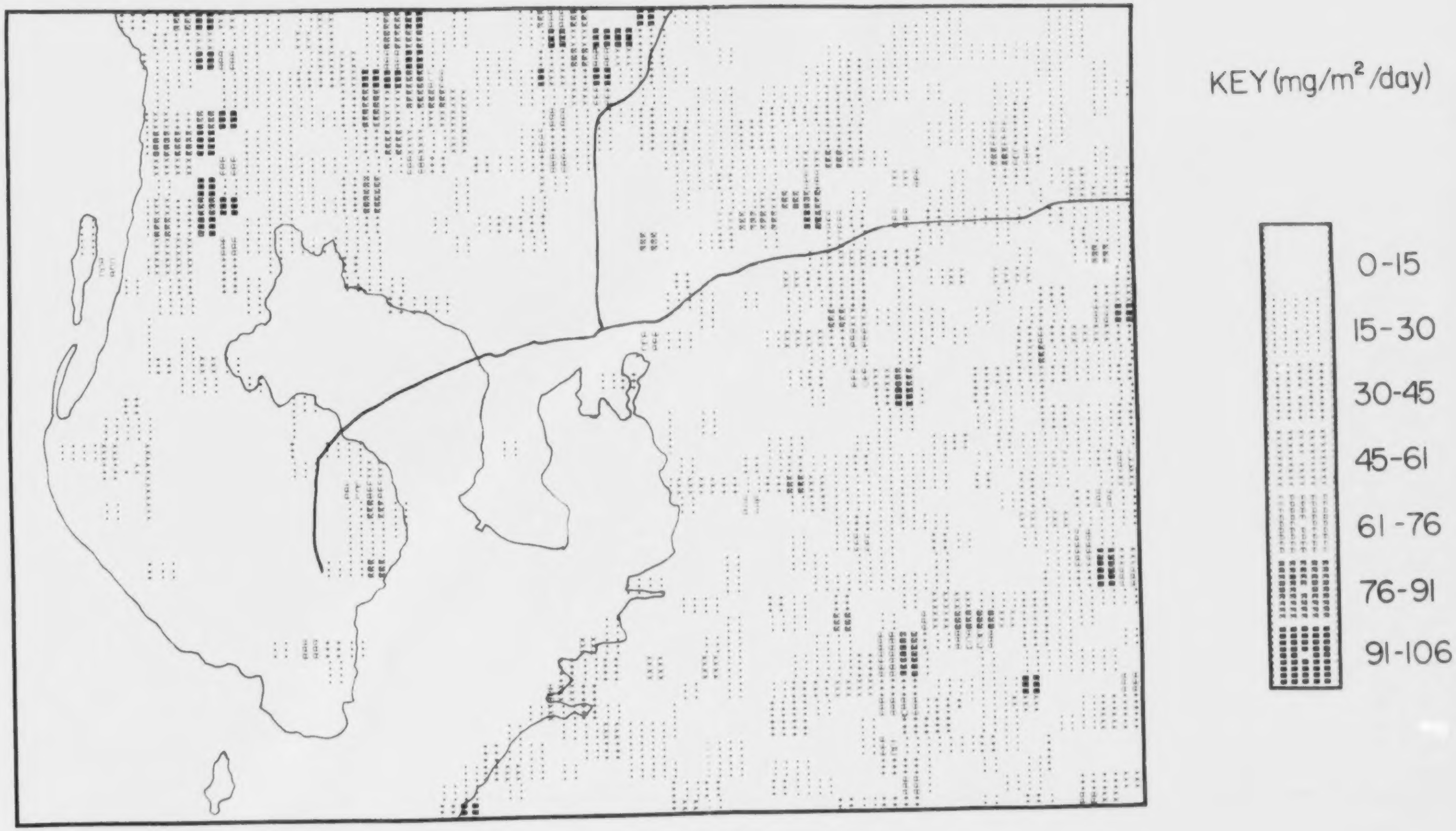

KEY (mg/m² /day)
0-15
15-30
30-45
45-61
61 -76
76-91
91-106

Figure 5.6-b

# TAMPA/ST.PETERSBURG BIOGENIC EMISSION DENSITY
## OLEFINS

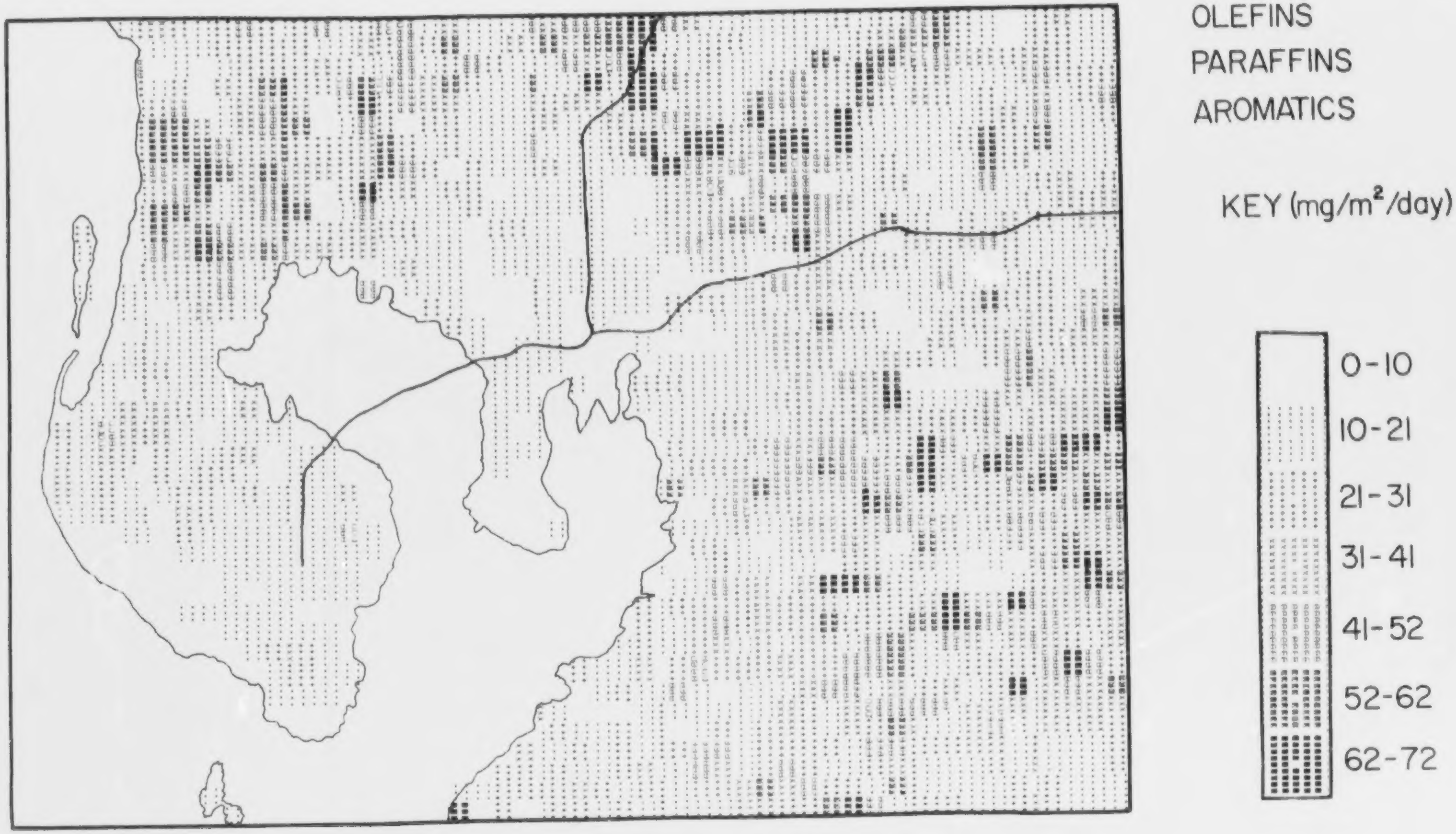

OLEFINS
PARAFFINS
AROMATICS
KEY (mg/m²/day)
0-10
10-21
21-31
31-41
41-52
52-62
62-72

Figure 5.6-c

# TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY

## PARAFFINS

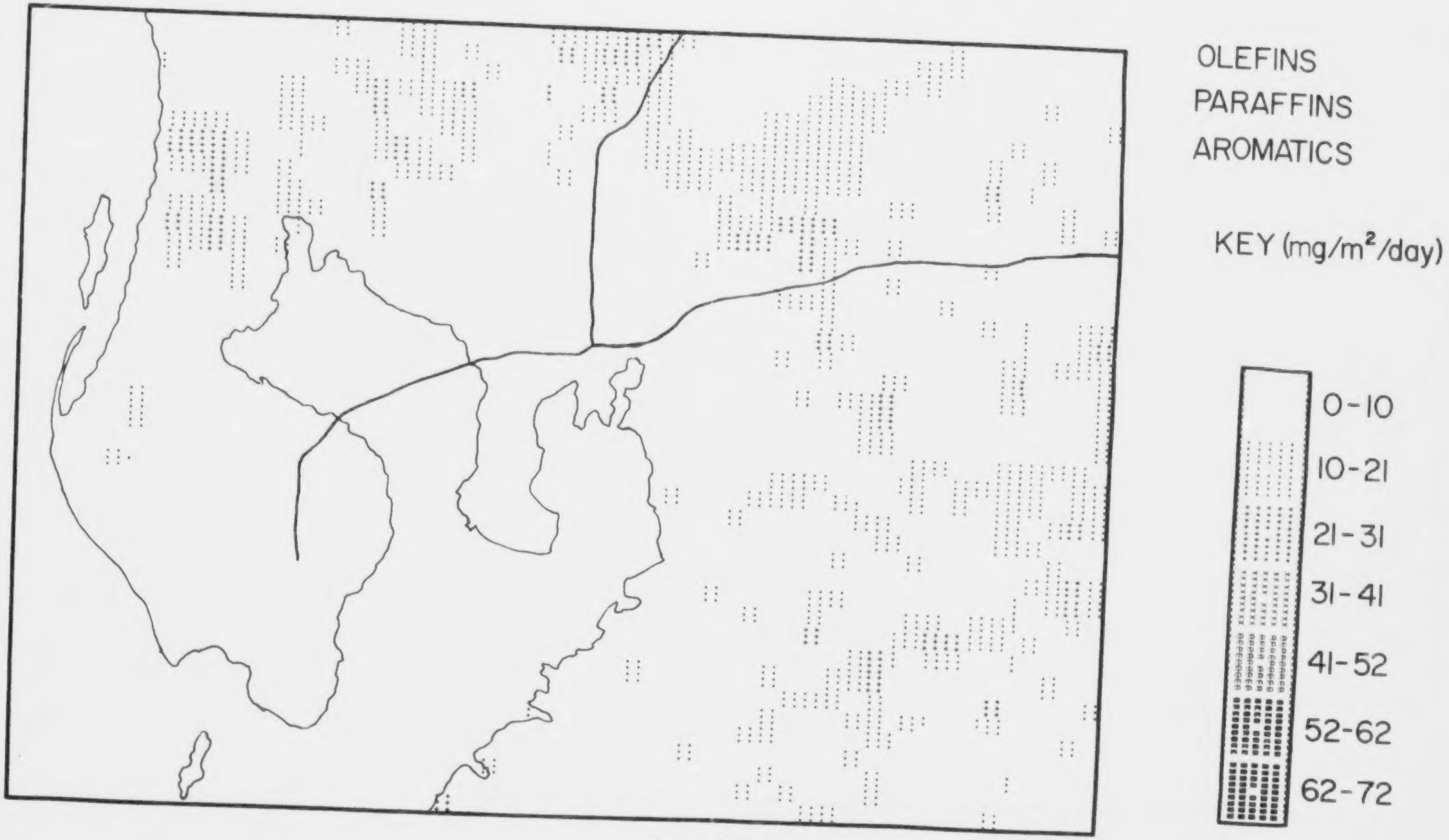

OLEFINS
PARAFFINS
AROMATICS
KEY (mg/m²/day)
0-10
10-21
21-31
31-41
41-52
52-62
62-72

Figure 5.6-d

## TAMPA/ST. PETERSBURG BIOGENIC EMISSION DENSITY
## AROMATICS

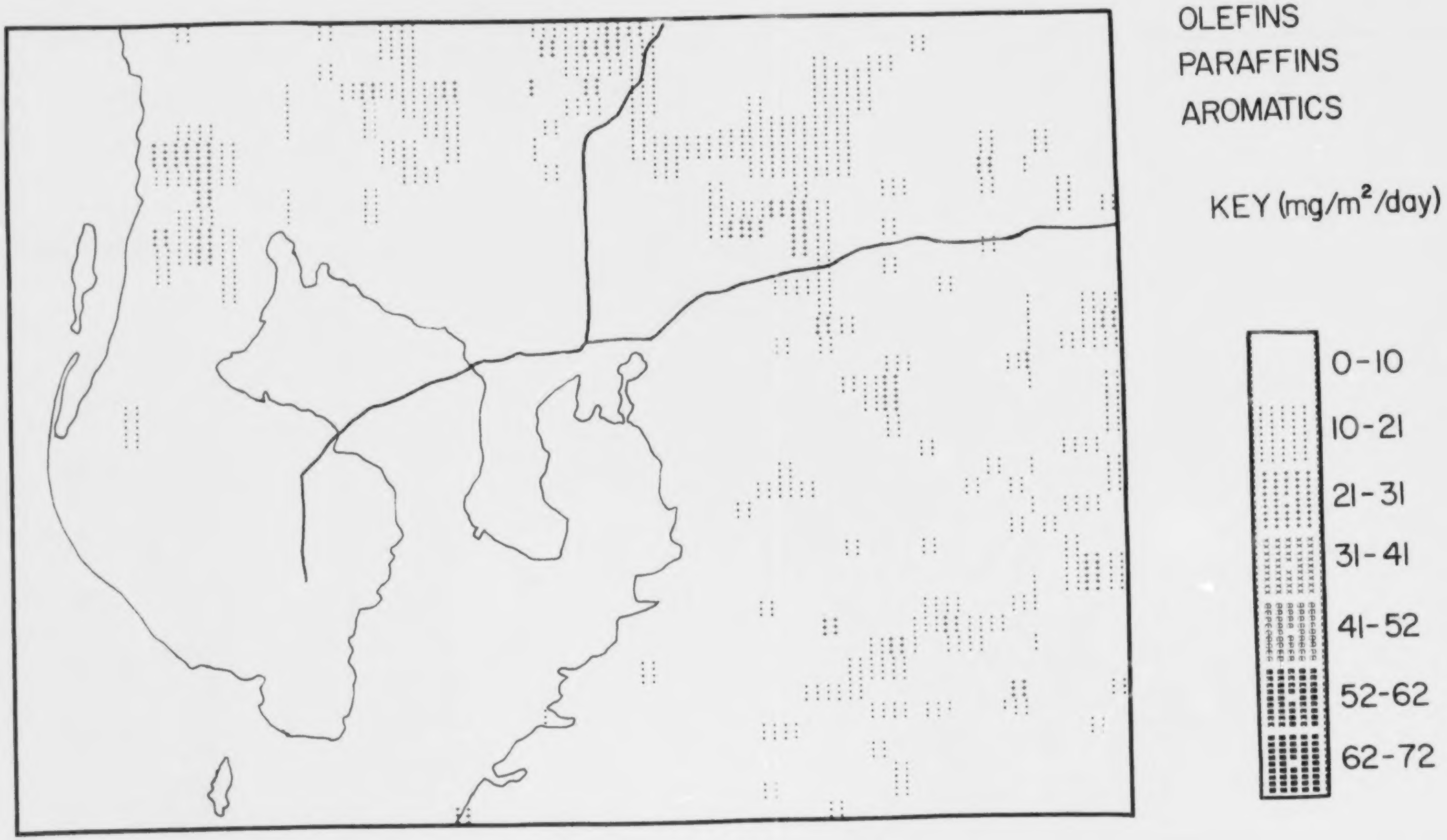

OLEFINS
PARAFFINS
AROMATICS
KEY (mg/m²/day)
0-10
10-21
21-31
31-41
41-52
52-62
62-72

Figure 5.6-e

The emission rates have also been calculated in terms of TNMHC, paraffins, olefins, aromatics, methane and for each major peak for each grid, and stored on a computer tape. The sum of the components does not add up exactly to the TNMHC due to errors in rounding introduced by the computer format (Section 5.2).

The separate grid emission rates have been summed for the day and the night data to result in an estimated hourly flux rate of each hydrocarbon component for the total study area for day and for night (Table 5.6-a). A rough approximation of the total average daily emission rate for the study area over the study period has been made (Table 5.6-b). This estimate is based upon the assumption of a 12-hour 30°C average daytime and 12-hour 25°C average night. More complex temperature regimes could be accommodated using the Tingey _et al._, emission rate algorithms for isoprene and the terpenes (Tingey, _et al_. 1978a&b). However, due to the uncertainty of the appropriateness of applying these algorithms to non-related species it is doubtful that the emission estimates could be improved at this time. The total daily (24 hours) emissions from each major vegetation type has also been summed over the entire study are using the same scheme (Table 5.6-c). A detailed tabulation of the total area occupied by each LUDA category and its percent of the study area is given in Appendix D.

Although arithmetic means were used to calculate the variability, it has been reported that a better estimate of raw data variability might result if the geometric mean were calculated instead of the arithmetic mean, since the data by Tingey, _et al._ 1978a&b, indicate that emission rates are log normally distributed. In this case the arithmetic mean and standard deviation would over estimate the actual sample variability. WSU chose to use the arithmetic mean and standard deviation since it is easier to manipulate statistically

Table 5.6-a AVERAGE HOURLY DAYTIME (30°C) AND NIGHTTIME (25°C) EMISSIONS FOR THE 81 X 60 km TAMPA/ST. PETERSBURG STUDY AREA

| | Daytime | | Nighttime | |
|---|---|---|---|---|
| Compound | Emission Factor ($\mu$g/hr) | Standard Deviation | Emission Factor ($\mu$g/hr) | Standard Deviation |
| TNMHC | $8.6 \times 10^{12}$ | $1.7 \times 10^{11}$ | $4.5 \times 10^{12}$ | $1.1 \times 10^{11}$ |
| Paraffins | $1.6 \times 10^{12}$ | $2.3 \times 10^{10}$ | $1.2 \times 10^{12}$ | $1.6 \times 10^{10}$ |
| Olefins | $5.6 \times 10^{12}$ | $1.5 \times 10^{11}$ | $2.3 \times 10^{12}$ | $1.0 \times 10^{11}$ |
| Aromatics | $1.4 \times 10^{12}$ | $1.9 \times 10^{10}$ | $1.0 \times 10^{12}$ | $1.3 \times 10^{10}$ |
| Methane | $4.1 \times 10^{12}$ | $1.3 \times 10^{11}$ | $4.1 \times 10^{12}$ | $1.3 \times 10^{11}$ |
| α-Pinene | $7.4 \times 10^{11}$ | $1.7 \times 10^{10}$ | $5.6 \times 10^{11}$ | $1.2 \times 10^{10}$ |
| β-Pinene | $4.0 \times 10^{11}$ | $1.4 \times 10^{10}$ | $2.9 \times 10^{11}$ | $9.4 \times 10^{9}$ |
| d-Limonene | $1.3 \times 10^{11}$ | $6.3 \times 10^{9}$ | $8.7 \times 10^{10}$ | $4.4 \times 10^{9}$ |
| Isoprene | $2.4 \times 10^{12}$ | $3.8 \times 10^{10}$ | 0.0 | 0.0 |
| Myrcene | $4.2 \times 10^{10}$ | $3.2 \times 10^{9}$ | $3.0 \times 10^{10}$ | $2.2 \times 10^{9}$ |
| Terpinolene | $1.9 \times 10^{9}$ | $1.1 \times 10^{8}$ | $1.9 \times 10^{9}$ | $1.1 \times 10^{8}$ |
| Unk. Terp. | $-4.0 \times 10^{9}$ | $2.7 \times 10^{9}$ | $-2.1 \times 10^{9}$ | $1.9 \times 10^{9}$ |
| Unk 10A | $6.2 \times 10^{8}$ | $1.3 \times 10^{8}$ | $6.2 \times 10^{8}$ | $1.3 \times 10^{8}$ |
| Unk 21A | $4.9 \times 10^{9}$ | - - - - | $3.4 \times 10^{9}$ | - - - - |
| Unk 16A | $1.3 \times 10^{9}$ | $3.1 \times 10^{8}$ | $8.8 \times 10^{8}$ | $2.1 \times 10^{8}$ |
| Unk 17 | $-3.0 \times 10^{7}$ | $1.5 \times 10^{6}$ | $-3.0 \times 10^{7}$ | $1.5 \times 10^{6}$ |
| Unk 18 | $5.7 \times 10^{8}$ | $1.0 \times 10^{8}$ | $4.1 \times 10^{8}$ | $6.9 \times 10^{7}$ |
| Unk 20 | $2.3 \times 10^{8}$ | $4.8 \times 10^{7}$ | $1.6 \times 10^{8}$ | $3.3 \times 10^{7}$ |
| Unk 21 | $2.7 \times 10^{11}$ | $2.4 \times 10^{10}$ | $1.9 \times 10^{11}$ | $1.7 \times 10^{10}$ |
| Unk 22 | $8.4 \times 10^{10}$ | $9.0 \times 10^{9}$ | $5.9 \times 10^{10}$ | $6.2 \times 10^{9}$ |
| Unk 23 | $3.8 \times 10^{9}$ | $2.2 \times 10^{8}$ | $2.6 \times 10^{9}$ | $1.6 \times 10^{8}$ |
| Unk 24 | $8.6 \times 10^{11}$ | $1.4 \times 10^{11}$ | $6.0 \times 10^{11}$ | $9.4 \times 10^{10}$ |
| Unk 25 | $7.1 \times 10^{9}$ | $1.7 \times 10^{9}$ | $4.9 \times 10^{9}$ | $1.2 \times 10^{9}$ |
| Unk 26 | $1.8 \times 10^{9}$ | $4.4 \times 10^{8}$ | $1.2 \times 10^{9}$ | $3.0 \times 10^{8}$ |
| Unk 27 | $8.4 \times 10^{9}$ | $7.3 \times 10^{8}$ | $5.8 \times 10^{9}$ | $5.0 \times 10^{8}$ |
| Unk 28 | $2.9 \times 10^{9}$ | $1.2 \times 10^{8}$ | $2.0 \times 10^{9}$ | $8.1 \times 10^{7}$ |
| Unk 29 | $1.9 \times 10^{9}$ | $1.5 \times 10^{8}$ | $1.1 \times 10^{9}$ | $1.0 \times 10^{8}$ |
| $\Delta^3$-Carene | $2.8 \times 10^{11}$ | $7.8 \times 10^{9}$ | $1.9 \times 10^{11}$ | $5.4 \times 10^{9}$ |
| Unk 26A | $3.4 \times 10^{10}$ | $4.6 \times 10^{9}$ | $2.4 \times 10^{10}$ | $3.2 \times 10^{9}$ |
| Unk 29A | $4.3 \times 10^{10}$ | $1.3 \times 10^{9}$ | $3.0 \times 10^{10}$ | $8.9 \times 10^{8}$ |

Table 5.6-b AVERAGE DAILY APRIL-AUGUST NATURAL EMISSION RATES FOR THE 81 X 60 km TAMPA/ST. PETERSBURG STUDY AREA (METRIC TONS)*

| Compound | Daytime<br>12 hr<br>Total | % | Nighttime<br>12 hr<br>Total | % | Daily<br>24 hr<br>Total | % |
|---|---|---|---|---|---|---|
| TNMHC | 103 | | 54 | | 157 | |
| Paraffins | 19 | 18 | 14 | 27 | 33.6 | 21 |
| Olefins | 67 | 67 | 28 | 52 | 94.8 | 60 |
| Aromatics | 17 | 15 | 12 | 21 | 28.8 | 18 |
| Methane | 49 | 33+ | 49 | 8+ | 98.4 | 29+ |
| Isoprene | 29 | 28 | 0 | 0 | 28.8 | 18 |
| α-Pinene | 8.9 | 9 | 6.7 | 13 | 15.6 | 10 |
| β-Pinene | 4.8 | 5 | 3.5 | 7 | 8.28 | 5 |
| $\Delta^3$-Carene | 3.4 | 3 | 2.3 | 4 | 5.56 | 4 |
| d-Limonene | 1.6 | 1 | 1.0 | 2 | 2.60 | 2 |
| Myrcene | 0.5 | 0.5 | 0.4 | 0.7 | 0.9 | 0.5 |

Average Daytime Flux = 1.71 $mg/m^2/hr$

Average Nighttime Flux = 0.93 $mg/m^2/hr$

Total Daily (24 hr) Average Flux = 32 $mg/m^2/day$

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*Calculations assume a 12 hour day, 30°C average leaf temperature and a 12 hour night, 25°C average leaf temperature (see text).

+% of TNMHC + methane

Table 5.6-c DAILY (24 Hr) BIOGENIC EMISSIONS BY MAJOR VEGETATION TYPES**

| Description | LUDA #s | Area (km$^2$) | % of Total Area | % of TNMHC | TNMHC (Kg/24 hr) | P (Kg/24 hr) | O (Kg/24 hr) | A (Kg/24 hr) | M (Kg/24 hr) |
|---|---|---|---|---|---|---|---|---|---|
| Residential | 11,22,28 | 729 | 15 | 16 | 25,258 | 5,891 | 13,171 | 6,160 | 533 |
| Cropland | *21(.5), 24 (.5), 25 | 240 | 5 | 2 | 3,138 | 917 | 1,771 | 450 | 1,568 |
| Pasture-Rangeland | 21(.5), 24 (.5), 26, 31, 32, 33 | 1243 | 26 | 19 | 29,691 | 6,127 | 18,849 | 4,620 | 14,715 |
| Citrus Groves | 29 | 286 | 6 | 22 | 34,925 | 7,743 | 19,534 | 7,686 | 30,933 |
| Deciduous Forest | 41, 43(.5), 61 | 13 | <1 | 1 | 1,485 | 232 | 1,070 | 185 | 367 |
| Evergreen Forest | 42, 421, 43 (.5), 612 | 555 | 11 | 35 | 55,356 | 8,077 | 40,866 | 6,273 | 14,412 |
| Mangroves | 6121 | 64 | 1 | 1 | 1,021 | 585 | 4 | 432 | 1,565 |
| Fresh water (aquatic) | 51, 52, 53 621, 27 | 130 | 3 | <1 | 497 | 211 | 24 | 263 | 17,435 |
| Salt water (marine) | 54, 55 | 1202 | 25 | 3 | 4,479 | 2,506 | 184 | 1,791 | 10,710 |
| Barren areas | 71-77 | 97 | 2 | <1 | 799 | 360 | 2 | 439 | 881 |
| Urban, Industrial & Transportation | 12-17 | 301 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTALS |  | 4,860 | 100 | 100 | 156,649 | 32,649 | 95,475 | 28,299 | 93,119 |

*Number in parenthesis denotes fraction of preceding LUDA included in this vegetation unit. For example: 21(.5) means half of LUDA 21 is included.

**For detailed daily emission profiles of individual LUDA categories see Appendix D.

and since a log-normal distribution of the field data was not apparent when the field data were compiled. The variability of the emission estimates by grid and of the total emissions from the study area were calculated assuming that all of the emission rate data was independent. However, some of the association values used in some of the LUDA emission estimates are positively correlated since they share some of the same species/sample types. Thus, the statistical standard deviation shown in Figure 5.6-a and Appendix C underestimates the actual statistical standard deviations. The degree of underestimation is positively related to the degree of dependence between vegetation associations. A "worst case" example was calculated for the hypothetical situation where associations A and B were assumed to be independent, but had a correlation coefficient of 1 (A=B). This example indicated that the standard deviations would be underestimated by only a factor of 1.4. Since the correlation coefficient for the associations and LUDA categories is much less than one, the assumption of independence causes the underestimation of the variability to be insignificant. Additionally, WSU could not differentiate or predict the effects of other field sample variables such as soil moisture or location upon emission rates. Therefore, the actual variability in the emission inventory is probably much greater than the statistical standard deviation shown in Table 5.6-a. The standard deviations for the various hydrocarbon compounds and classes in the table indicate that the emission factor variability is less than a factor of two. It should be stressed that this only reflects the variability between the raw sample emission rates that were used in the emission inventory. Uncertainties in vegetation composition, the emissions of species not sampled and uncertainties in leaf biomass estimation are all more difficult to evaluate. Although every attempt was made to accurately evaluate each element in this inventory and to treat uncertainties conservatively, the final figures reflected in Tables 5.6-a and 5.6-b could probably differ from actual natural emissions by a factor of two. More sampling is needed to narrow this variability further. Improvements in the emission rate algorithms could be applied at a later date to increase the accuracy of these estimates. Ambient air sampling should be done in the study area and the concentrations of the natural emission products should be related to meteorological parameters to determine if they are commensurate with the emission estimates made during the course of this study. Finally, since the climatic conditions before and during the study were somewhat atypical (very cold winter preceeding a very dry summer), spot checks of emission rates should be made in future years to confirm that the emission rates measured during the course of this study are representative.

Although uncertainty in the projected emission estimates still exists, this study is the most comprehensive program of its type ever attempted. The resultant emission estimates developed as a result of this study probably are the most accurate area-wide estimates of natural hydrocarbon emissions made to date for a large heterogeneous area.

# 6. DESCRIPTION OF COMPUTER PROGRAMS, FILES AND TAPES

Two computer tapes were generated as a result of this study. The WSU tape contains all of the raw data, files of the refined emission factors, programs to generate those factors and emission rates by grid. The other tape submitted to Region IV, contains only the emission factors by grid.

Computer manipulations were aided by SAS, a statistical analysis computer package (Barr, et al, 1976).

## 6.1 EPA GRID EMISSION DATA TAPE

A computer tape of emission rates by grid was prepared according to EPA specifications and has been forwarded to Region IV. The tape is non labeled, 7-track, 556 BPI EBCDIC, even parity LRECL = 80 RECFM = FB BLK SIZE = 2400.

The tape contains the following information:

File 1: Daytime Grid Emission Rates

DSN = USER. Y6401. Emission. Grid. Daytime

File 2: Nighttime Grid Emission Rates

DSN = USER. Y6401. Emission. Grid. Nighttime

column 1-5: Grid #, character data

column 6-7: compound, character data

column 8-23: Emission rate, E notation

## 6.2 WSU TAMPA/ST. PETERSBURG EMISSION STUDY TAPE

The following section describes the location and format for all of the files and programs used to generate those files from the original data.

The data are stored at WSU on magnetic tape volume number CC1587. The tape is in standard labled, 1600 BPI, 9-track format. All files are in fixed block (FB) form with logical record lengths (LRECL) and block sizes (BLK SIZE) as indicated in Table 6.2-a.

## 6.3 DIRECTIONS FOR USE OF WSU TAMPA/ST. PETERSBURG STUDY TAPE VOLCC1587

The programs described should be put in a Wylbur or other disk library before use. They should be run in the order shown in Figure 6.3-a, although it is not required to start at the beginning. The Job Control Language (JCL) associated with each program assumes that all data sets being read exist in catalogued data sets on disk and that each data set to be written does not currently exist and will be created on disk (except the GRID emission rate data sets which are so large that it is better to write them to tape). If these written data sets are to be rewritten, the associated Data Definition (DD), card can be changed so that just the Data Set Name, (DSN) parameter and DISP = OLD need be coded. For example, the FT10F001 DD card in the program to generate the ASSN emission rates would appear as:

```
11GO FT10F001  DD DSN = USER. Y4313. Emission, Day ASSN, DISP = OLD
```

All the data sets and programs listed here are also on tape volume number CC1587. They can be accessed directly from the tape, although the unit and volume parameters must be specified since these data sets are not catalogued (the unit is UNIT = TAPE). Data sets can be written to this tape, but it is recommended that writing is done after the existing data sets on the tape. Writing over an existing file will also destroy all files after the rewritten one.

## Table 6.2-a CONTENTS OF WSU TAMPA/ST. PETERSBURG EMISSION STUDY TAPE

| File Number | Date Set Name | Block Count | Block Size | Logical Record Length |
|---|---|---|---|---|
| 1 | .EMISSION.RAWDATA | 17 | 3120 | 80 |
| 2 | 6401.EMISSION.DAY | 8 | 6400 | 80 |
| 3 | 01.EMISSION.NIGHT | 8 | 6400 | 80 |
| 4 | .EMISSION.DAYMEAN | 65 | 2400 | 80 |
| 5 | EMISSION.NIGHTMEAN | 65 | 2400 | 80 |
| 6 | 401.EMISSION.ASSN | 1 | 1090 | 10 |
| 7 | .EMISSION.DAYASSN | 13 | 2400 | 80 |
| 8 | EMISSION.NIGHTASSN | 13 | 2400 | 80 |
| 9 | 401.EMISSION.LUDA | 1 | 1352 | 13 |
| 10 | .EMISSION.DAYLUDA | 32 | 2400 | 80 |
| 11 | EMISSION.NIGHTLUDA | 32 | 2400 | 80 |
| 12 | EMISSION.AIRGRIDS | 56 | 3120 | 80 |
| 13 | .EMISSION.DAYGRID | 1 | 2400 | 80 |
| 14 | EMISSION.NIGHTGRID | 1 | 2400 | 80 |
| 15 | SION.GRID.DAYTIME | 2160 | 2400 | 80 |
| 16 | ION.GRID.NIGHTTIME | 2160 | 2400 | 80 |
| 17 | L.EMISSION.APRFIX | 4 | 2400 | 80 |
| 18 | EMISSION.APRMEANS | 3 | 2400 | 80 |
| 19 | .EMISSION.APRASSN | 2 | 2400 | 80 |
| 20 | .EMISSION.APRDATA | 1 | 2400 | 80 |
| 21 | .EMISSION.APRLUDA | 4 | 2400 | 80 |
| 22 | EMISSION.APRDATA2 | 1 | 2400 | 80 |
| 23 | .EMISSION.APRGRID | 3 | 2400 | 80 |
| 24 | EMISSION.APRDATA3 | 1 | 2400 | 80 |

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)

| | | |
|---|---|---|
| USER. Y4313. EMISSION. RAWDATA | catalogued | |
| USER. Y6401. EMISSION. RAWDATA | tape VOL=SER=CC1587 | file 1 |

Contents: Original raw data. The original data is coded as described in Section 5.2.

| | | |
|---|---|---|
| USER. Y4313. EMISSION. DAY | catalogued | |
| USER. Y6401. EMISSION. DAY | tape VOL=SER=CC1587 | file 2 |

Contents: Original data corrected to a standard 30°C daytime temperature. The format of the data is the same as for original data.

| | | |
|---|---|---|
| USER. Y4313. EMISSION. NIGHT | catalogued | |
| USER. Y6401. EMISSION. NIGHT | tape VOL=SER=CC1587 | file 3 |

Contents: Original data corrected to a standard 25°C nighttime temperature. The format of data is the same as for the original data.

| | | |
|---|---|---|
| USER. Y4313. EMISSION. DAYMEAN | catalogued | |
| USER. Y6401. EMISSION. DAYMEAN | tape VOL=SER=CC1587 | file 4 |

Contents: Daytime species mean emission rates

Format:

| | | |
|---|---|---|
| Species | columns 1-3 | |
| Compound | columns 4-5 | character data |
| Rate | columns 6-15 | E notation |
| Variance | columns 16-25 | E notation |

| | | |
|---|---|---|
| USER. Y4313. EMISSION. NIGHTMEAN | catalogued | |
| USER. Y6401. EMISSION. NIGHTMEAN | tape VOL=SER=CC1587 | file 5 |

Contents: Nighttime species mean emission rates. The format is the same as for the daytime means.

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

| | | |
|---|---|---|
| USER. Y4313. EMISSION. ASSN | catalogued | |
| USER. Y6401. EMISSION. ASSN | tape VOL=SER=CC1587 | file 6 |

Contents: ASSN factor data sorted by species

| Format: | | |
|---|---|---|
| ASSN | column 1 | character data |
| SPECIES | columns 2-4 | |
| FACTOR | columns 5-10 | |

| | | |
|---|---|---|
| USER. Y4313. EMISSION. DAYASSN | catalogued | |
| USER. Y6401. EMISSION. DAYASSN | tape VOL=SER=CC1587 | file 7 |

Contents: Daytime ASSN emission rates

| Format: | | |
|---|---|---|
| ASSN | column 1 | character data |
| COMPOUND | columns 2-3 | character data |
| RATE | columns 4-11 | hexadecimal floating point data (FORTRAN real Z form) |
| VARIANCE | columns 20-27 | hexadecimal floating point data |

| | | |
|---|---|---|
| USER. Y4313. EMISSION. NIGHTASSN | catalogued | |
| USER. Y6401. EMISSION. NIGHTASSN | tape VOL=SER=CC1587 | file 8 |

Contents: Nighttime ASSN emission rates.

Format: the same as for the daytime ASSN rates.

| | | |
|---|---|---|
| USER. Y4313. EMISSION. LUDA | catalogued | |
| USER. Y6401. EMISSION. LUDA | tape VOL=SER=CC1587 | file 9 |

Contents: LUDA factor data sorted by ASSN - SPECIES

| Format: | | | |
|---|---|---|---|
| LUDA | columns 1-4 | | |
| ASSN | column 5 | character data | 1st 41 records |
| SPECIES | columns 5-7 | | remaining records |
| FACTOR | columns 8-13 | | |

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

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USER. Y4313. EMISSION. DAY LUDA catalogued

USER. Y6401. EMISSION. DAY LUDA tape VOL=SER=CC1587 file 10

Contents: Daytime LUDA emission rates.

Format:

| | | |
|---|---|---|
| LUDA | columns 1-4 | |
| COMPOUND | columns 5-6 | character data |
| RATE | columns 7-14 | hexadecimal floating point data (FORTRAN real Z form) |
| VARIANCE | columns 23-30 | hexadecimal floating point data |

USER. Y4313. EMISSION. NIGHT LUDA catalogued

USER. Y6401. EMISSION. NIGHT LUDA tape VOL=SER=CC1587 file 11

Contents: Nighttime LUDA emission rates

Format: the same as for the daytime LUDA rates.

USER. Y4313. EMISSION. AIR GRIDS catalogued

USER. Y6401. EMISSION. AIR GRIDS tape VOL=SER=CC1587 file 12

Contents: GRID LUDA factor data.

USER. Y4313. EMISSION. DAY GRIDS catalogued

USER. Y6401. EMISSION. DAY GRIDS tape VOL=SER=CC1587 file 13

Contents: Daytime final total emission rates

Format:

| | | |
|---|---|---|
| COMPOUND | columns 1-2 | character data |
| RATE | columns 3-10 | hexadecimal floating point data |
| VARIANCE | columns 19-26 | hexadecimal floating point data |

USER. Y4313. EMISSION. NIGHT GRIDS catalogued

USER. Y6401. EMISSION. NIGHT GRIDS tape VOL=SER=CC1587 file 14

Contents: Nighttime final total emission rates.

Format: the same as for the daytime total emission rates.

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

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USER. Y6401. EMISSION. GRID. DAYTIME tape VOL=SER=CC1587 file 15

Contents: Daytime GRID emission rates.

Format:

| | | |
|---|---|---|
| GRID | columns 1-5 | character data |
| COMPOUND | columns 6-7 | character data |
| RATE | columns 8-23 | E notation |

USER. Y6401. EMISSION. GRID. NIGHTTIME Tape VOL=SER=CC1587 file 16

Contents: Nighttime GRID emission rates

Format: the same as for the daytime GRID rates.

WYL. SS. RAK. JOBS (APRFIX) catalogued
USER. Y6401. EMISSION. APRFIX Tape VOL=SER=CC1587 file 17

Contents: Program to correct original data for daytime and nighttime temperatures.

The EMISSION DD card defines the data set containing the original data.

The DAY DD card defines the data set which will contain the daytime corrected original emission rates.

The NIGHT DD card defines the data set which will contain the nighttime corrected original emission rates.

WYL. SS. RAK. JOBS (APRMEANS) catalogued
USER. Y6401. EMISSION. APRFIX Tape VOL=SER=CC1587 file 18

Contents: Program to determine and print specie means. Run once for day and once for night data, making the appropriate changes in the following DD cards and the TITLE statement.

The EMISSION DD card defines the data set containing the corrected day or night data.

The DAYMEAN DD defines the data set which will contain the day or night specie means.

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

---

| | | |
|---|---|---|
| WYL. SS. RAK. JOBS (APRASSN) | catalogued | |
| USER. Y6401. EMISSION. APRASSN | Tape VOL=SER=CC1587 | file 19 |

Contents: Program to generate ASSN emission rates. Run once for day and once for night data. Minor change in some DD cards are required for night data.

The FT08F001 DD card defines ASSN factor data sorted by species.
The FT09F001 DD card defines day or night species mean emission rates.
The FT10F001 DD card defines the data set which will contain the day or night ASSN emission rates.

| | | |
|---|---|---|
| WYL. SS. RAK. JOBS (APRDATA) | catalogued | |
| USER. Y6401. EMISSION. APRDATA | Tape VOL=SER=CC1587 | file 20 |

Contents: Program to print ASSN emission rates.

The DAYASSN DD card defines the data set containing daytime ASSN emission rates.

The NIGHTASSN DD card defines the data set containing nighttime ASSN emission rates.

| | | |
|---|---|---|
| WYL. SS. RAK. JOBS (APRLUDA) | catalogued | |
| USER. Y6401. EMISSION. APRLUDA | Tape VOL=SER=CC1587 | file 21 |

Contents: Program to generate LUDA emission rates. Run once for day and once for night data. Determination for LUDA's 22, 28, 43 are built in.

The FT08F001 DD card defines LUDA factor data sorted by ASSN-SPECIE.
The FT09F001 DD card defines the data set which contains day or night ASSN emission rates.

The FT10F001 DD card defines the data set which contains the day or night specie mean emission rates.

The FT11F001 DD card defines the data set which will contain the day or night LUDA emission rates. WYL. SS. RAK. JOBS (APRLUDA)

Figure 6.3-a List of files and programs for Tampa/St. Petersburg study (Tape vol. CC1587)(continued).

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WYL. SS. RAK. JOBS (APRDATAZ) catalogued
USER. Y6401. EMISSION. APRDATAZ Tape VOL=SER=CC1587 file 22

Contents: Program to print LUDA emission rates

The DAYLUDA DD card defines the data set containing daytime LUDA emission rates.

The NIGHTLUDA DD card defines the data set containing nighttime LUDA emission rates.

WYL. SS. RAK. JOBS (APRGRID) catalogued
USER. Y6401. EMISSION. APRGRID Tape VOL=SER=CC1587 file 23

Contents: Program to generate GRID and TOTAL emission rates. Run once for day and once for night data.

The FT08F001 DD card defines the data set which contains the GRID factor data.

The FT09F001 DD card defines the data set which will contain the day or night GRID emission rates. The tape volume serial number will have to be supplied. If operator attempts to write on CC1587, the label will have to be changed so that previous data does not get destroyed. Note also, the night label must be different from the day label.

The FT11F001 DD card defines the data set which contains the day or night LUDA emission rates.

The FT12F001 DD card defines the data set which will contain the day or night TOTAL emission rates.

WYL. SS. RAK. JOBS (APRDATAZ) catalogued
USER. Y6401. EMISSION. APRDATAZ Tape VOL=SER=CC1587 file 24

Contents: Program to print TOTAL emission rates.

The DAYGRID DD card defines the data set containing daytime TOTAL emission rates.

The NIGHTGRID DD card defines the data set containing nighttime TOTAL emission rates.

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# APPENDIX A

## INTRODUCTION

This appendix contains the average emission rates for day and for night of each species/sample type used to compile the emission inventory. The "compound" column lists the compounds for which emission rates were calculated. "TNMHC" means total non-methane hydrocarbons; "Parafins", "Olefins", "Aromatics" and "Methane" are classes of compounds as described in Section 1.2.2. Other compounds such as "α-Pinene" designate major peaks. Some of those include unknowns. In these cases the peak identity (eg #21) is preceeded by UNK. The column labeled "N" designates the number of samples. In some cases N is smaller for one compound than another. This is due to analytical problems which required the omission of a sample. $\overline{X}$ designates the mean of the emission samples calculated as $(\Sigma x_1 + x_2 . . . . + x_n)/n$. SD designates the standard deviation of the emission samples, calculated as the square root of the variance. N denotes the number of samples used to calculate the mean.

The name of each species/sample type is shown above its set of emission rates followed by its scientific code and the units of measurement. μg/g/hr means micrograms emission per gram leaf biomass dry wt per hour. The heading $\mu g/m^2/hr$ means micrograms emissions per square meter surface per hour.

Emission rates for row crops were collected in June and July after harvest. These emission rates therefore do not include fruit and may not be representative of actual emissions during the growing season.

For "wet" categories such as "grassy mudflat (Marine) 0"-2" water 901," the title designates an an area of salt water where marine grass occurred that had a water depth of from 0" to 2" during the time that the samples were collected. Similarly, category 905 designates samples collected over an area where the bottom was sandy and the water depth was greater than five feet. Categories 901 to 931 designate salt water areas, while 941-944 designate fresh water samples. Category 950 is a sample collected while the tide was out on an oyster bed.

# APPENDIX A

## Emission Rate Means by Species Standardized to 30°C (day) and 25°C (night)

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Black Mangrove 001 (μg/g/hr) | | | | | | |
| TNMHC | 3 | 1.344 | 0.426 | 3 | 0.932 | 0.294 |
| Paraffins | 3 | 0.429 | 0.082 | 3 | 0.298 | 0.057 |
| Olefins | 3 | 0 | 0 | 3 | 0 | 0 |
| Aromatics | 3 | 0.917 | 0.475 | 3 | 0.638 | 0.331 |
| Methane | 3 | -0.301 | 0.225 | 3 | -0.301 | 0.225 |
| Name: White Mangrove 011 (μg/g/hr) | | | | | | |
| TNMHC | 18 | 1.172 | 0.701 | 18 | 0.814 | 0.488 |
| Paraffins | 18 | 0.692 | 0.519 | 18 | 0.480 | 0.361 |
| Olefins | 18 | 0 | 0 | 18 | 0 | 0 |
| Aromatics | 18 | 0.480 | 0.301 | 18 | 0.333 | 0.208 |
| Methane | 18 | 1.514 | 3.369 | 18 | 1.514 | 3.369 |
| Name: Red Mangrove 021 (μg/g/hr) | | | | | | |
| TNMHC | 16 | 1.000 | 0.744 | 16 | 0.695 | 0.516 |
| Paraffins | 16 | 0.596 | 0.552 | 16 | 0.414 | 0.384 |
| Olefins | 16 | 0.006 | 0.020 | 16 | 0.004 | 0.016 |
| Aromatics | 16 | 0.400 | 0.376 | 16 | 0.278 | 0.252 |
| Methane | 15 | 1.361 | 1.371 | | | |
| Name: Slash Pine 101 (μg/g/hr) | | | | | | |
| TNMHC | 16 | 4.069 | 3.884 | 16 | 2.824 | 2.696 |
| Paraffins | 16 | 0.566 | 0.608 | 16 | 0.393 | 0.424 |
| Olefins | 16 | 3.216 | 3.536 | 16 | 2.235 | 2.456 |
| Aromatics | 16 | 0.287 | 0.312 | 16 | 0.200 | 0.216 |
| Methane | 16 | 0.816 | 0.952 | 16 | 0.816 | 0.952 |
| α-Pinene | 16 | 0.966 | 1.008 | 16 | 0.670 | 0.700 |
| β-Pinene | 16 | 0.900 | 1.648 | 16 | 0.625 | 1.144 |
| d-Limonene | 16 | 0.291 | 0.432 | 16 | 0.202 | 0.300 |
| $\Delta^3$-Carene | 16 | 0.462 | 0.976 | 16 | 0.301 | 0.676 |

|  | Day |  |  | Night |  |  |
|---|---|---|---|---|---|---|
| Compound | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Name: Longleaf Pine 102 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 29 | 7.265 | 11.680 | 29 | 5.048 | 8.121 |
| Paraffins | 28 | 0.802 | 1.005 | 28 | 0.557 | 0.698 |
| Olefins | 28 | 5.894 | 11.424 | 28 | 4.091 | 7.921 |
| Aromatics | 28 | 0.384 | 0.444 | 28 | 0.266 | 0.307 |
| Methane | 28 | 0.321 | 0.639 | 28 | 0.321 | 0.693 |
| α-Pinene | 29 | 2.416 | 5.175 | 29 | 1.679 | 3.597 |
| β-Pinene | 29 | 2.871 | 5.945 | 29 | 1.993 | 4.125 |
| d-Limonene | 29 | 0.087 | 0.226 | 29 | 0.060 | 0.156 |
| Myrcene | 29 | 0.001 | 0.005 | 29 | 0.001 | 0.003 |
| $\Delta^3$-Carene | 29 | 0.176 | 0.716 | 29 | 0.122 | 4.971 |
| Name: Sand Pine 103 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 4 | 13.558 | 16.558 | 4 | 9.428 | 11.518 |
| Paraffins | 4 | 1.516 | 0.908 | 4 | 1.052 | 0.628 |
| Olefins | 4 | 11.650 | 15.388 | 4 | 8.088 | 10.684 |
| Aromatics | 4 | 0.386 | 0.456 | 4 | 0.268 | 0.316 |
| Methane | 4 | 1.575 | 2.626 | 4 | 1.575 | 2.626 |
| α-Pinene | 4 | 4.783 | 6.284 | 4 | 3.315 | 4.354 |
| β-Pinene | 4 | 6.188 | 9.184 | 4 | 4.302 | 6.388 |
| Name: Southern Red Pine 104 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 1 | 2.910 | --- | 1 | 2.020 | --- |
| Paraffins | 1 | 1.560 | --- | 1 | 1.090 | --- |
| Olefins | 1 | 0.067 | --- | 1 | 0.047 | --- |
| Aromatics | 1 | 1.290 | --- | 1 | 0.894 | --- |
| Methane | 1 | 0.325 | --- | 1 | 0.325 | --- |
| α-Pinene | 1 | 0.068 | --- | 1 | 0.047 | --- |

|  | Day |  |  | Night |  |  |
|---|---|---|---|---|---|---|
| Compound | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Name: Cypress 112 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 20 | 14.159 | 9.816 | 20 | 9.838 | 6.816 |
| Paraffins | 20 | 3.214 | 3.318 | 20 | 2.232 | 2.303 |
| Olefins | 20 | 8.486 | 9.942 | 20 | 5.902 | 6.923 |
| Aromatics | 20 | 2.448 | 2.419 | 20 | 1.701 | 1.677 |
| Methane | 20 | 3.230 | 5.765 | 20 | 3.230 | 5.765 |
| α -Pinene | 20 | 4.362 | 7.231 | 20 | 3.032 | 5.018 |
| β -Pinene | 20 | 0.058 | 0.165 | 20 | 0.040 | 0.116 |
| d -Limonene | 20 | 0.272 | 0.452 | 20 | 0.189 | 0.313 |
| Myrcene | 20 | 0.282 | 0.783 | 20 | 0.196 | 0.541 |
| Unk Terp. | 20 | 0.278 | 1.243 | 20 | 0.193 | 0.863 |
| Unk #22 | 20 | 0.072 | 0.322 | 20 | 0.050 | 0.224 |
| Unk #27 | 20 | 0.145 | 0.648 | 20 | 0.100 | 0.447 |
| $\Delta^3$-Carene | 20 | 2.810 | 4.571 | 20 | 1.949 | 3.180 |
| Name: Laurel Oak 201 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 10 | 12.633 | 13.753 | 12 | 1.609 | 2.562 |
| Paraffins | 10 | 1.405 | 1.940 | 12 | 0.872 | 1.244 |
| Olefins | 10 | 10.174 | 10.705 | 12 | 0.111 | 0.704 |
| Aromatics | 10 | 1.034 | 1.224 | 12 | 0.622 | 0.800 |
| Methane | 9 | 1.988 | 1.563 | 11 | 1.703 | 1.547 |
| α-Pinene | 10 | 0.022 | 0.071 | 12 | 0.013 | 0.045 |
| Isoprene | 10 | 9.996 | 10.120 | 12 | 0 | 0 |
| Name: Water Oak 202 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 3 | 26.683 | 22.680 | 3 | 2.054 | 1.991 |
| Paraffins | 3 | 1.236 | 0.667 | 3 | 0.857 | 0.461 |
| Olefins | 3 | 23.797 | 20.134 | 3 | 0.061 | 0.162 |
| Aromatics | 3 | 1.626 | 2.138 | 3 | 1.129 | 1.485 |
| Methane | 3 | -1.427 | 14.903 | 3 | -1.427 | 14.903 |
| Isoprene | 3 | 23.713 | 19.913 | 3 | 0 | 0 |

|  | Day |  |  | Night |  |  |
|---|---|---|---|---|---|---|
| Compound | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Name: Turkey Oak 203 (μg/g hr) |  |  |  |  |  |  |
| TNMHC | 7 | 26.500 | 19.104 | 7 | 2.126 | 2.602 |
| Paraffins | 7 | 1.215 | 1.258 | 7 | 0.844 | 0.873 |
| Olefins | 7 | 24.213 | 17.572 | 7 | 0.550 | 1.030 |
| Aromatics | 7 | 1.040 | 1.178 | 7 | 0.722 | 0.818 |
| Methane | 7 | 1.095 | 1.925 | 7 | 1.095 | 1.925 |
| α-Pinene | 7 | 0.373 | 0.649 | 7 | 0.258 | 0.449 |
| β-Pinene | 7 | 0.152 | 0.266 | 7 | 0.106 | 0.185 |
| Isoprene | 7 | 23.434 | 17.418 | 7 | 0 | 0 |
| Name: Live Oak 204 (μg/g hr) |  |  |  |  |  |  |
| TNMHC | 18 | 10.789 | 7.701 | 21 | 1.362 | 1.379 |
| Paraffins | 18 | 0.[illegible] | 0.603 | 21 | 0.439 | 0.408 |
| Olefins | 18 | 9.44[illegible] | 7.413 | 21 | 0.505 | 1.406 |
| Aromatics | 18 | 0.654 | 0.595 | 21 | 0.419 | 0.393 |
| Methane | 18 | 0.998 | 2.931 | 21 | 0.824 | 2.738 |
| α-Pinene | 18 | 0.054 | 0.209 | 21 | 0.140 | 0.506 |
| β-Pinene | 18 | 0.061 | 0.229 | 21 | 0.175 | 0.642 |
| Isoprene | 18 | 9.083 | 7.662 | 21 | 0 | 0 |
| Unk #29 | 18 | 0.081 | 0.187 | 21 | 0.048 | 0.121 |
| Name: Bluejack Oak 206 (μg/g hr) |  |  |  |  |  |  |
| TNMHC | 7 | 56.411 | 56.749 | 7 | 8.659 | 8.482 |
| Paraffins | 7 | 6.862 | 6.855 | 7 | 4.767 | 4.766 |
| Olefins | 7 | 44.193 | 45.113 | 7 | 0.170 | 0.208 |
| Aromatics | 7 | 5.317 | 6.133 | 7 | 3.696 | 4.272 |
| Methane | 5 | 0.737 | 2.850 | 5 | 0.737 | 2.850 |
| Isoprene | 7 | 43.909 | 44.833 | 7 | 0 | 0 |

|  | Day |  |  | Night |  |  |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Myrtle Oak 207 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 1 | 17.200 | --- | 1 | 1.800 | --- |
| Paraffins | 1 | 1.310 | --- | 1 | 0.912 | --- |
| Olefins | 1 | 14.800 | --- | 1 | 0.120 | --- |
| Aromatics | 1 | 1.080 | --- | 1 | 0.750 | --- |
| Methane | 1 | 3.060 | --- | 1 | 3.060 | --- |
| Isoprene | 1 | 14.60 | --- | 1 | 0 | 0 |
| Name: Willow Oak 208 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 1 | 32.600 | --- | 1 | 1.120 | --- |
| Paraffins | 1 | 1.010 | --- | 1 | 0.704 | --- |
| Olefins | 1 | 31.000 | --- | 1 | 0 | 0 |
| Aromatics | 1 | 0.624 | --- | 1 | 0.433 | --- |
| Methane | 1 | 7.120 | --- | 1 | 7.120 | --- |
| Isoprene | 1 | 31.000 | --- | 1 | 0 | 0 |
| Name: Saw Palmetto 301 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 35 | 11.547 | 17.932 | 36 | 2.040 | 2.142 |
| Paraffins | 35 | 1.300 | 2.121 | 36 | 0.888 | 1.449 |
| Olefins | 35 | 8.667 | 14.447 | 36 | 0.048 | 0.131 |
| Aromatics | 35 | 1.590 | 2.581 | 36 | 1.101 | 1.771 |
| Methane | 32 | 2.323 | 4.264 | 33 | 2.258 | 4.213 |
| α-Pinene | 35 | -0.006 | 0.037 | 36 | -0.004 | 0.027 |
| Isoprene | 35 | 8.595 | 14.349 | 36 | 0 | 0 |
| Unk #18 | 35 | 0.014 | 0.081 | 36 | 0.009 | 0.055 |
| Unk #20 | 35 | 0.007 | 0.039 | 36 | 0.004 | 0.027 |
| Unk #22 | 35 | 0.308 | 1.289 | 36 | 0.208 | 0.884 |
| Name: Sabal Palmetto 311 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 12 | 7.452 | 3.977 | 14 | 1.861 | 3.289 |
| Paraffins | 11 | 1.266 | 2.941 | 13 | 0.803 | 1.864 |
| Olefins | 11 | 4.916 | 2.542 | 13 | 0.023 | 0.064 |
| Aromatics | 11 | 0.786 | 1.330 | 13 | 0.498 | 0.851 |
| Methane | 12 | 0.641 | 1.259 | 14 | 0.552 | 1.180 |
| Isoprene | 12 | 4.470 | 2.842 | 14 | 0 | 0 |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Wax Myrtle 401 (μg/g/hr) | | | | | | |
| TNMHC | 9 | 7.477 | 5.395 | 9 | 5.191 | 3.745 |
| Paraffins | 9 | 0.754 | 0.555 | 9 | 0.523 | 0.385 |
| Olefins | 9 | 6.287 | 4.816 | 9 | 4.371 | 3.350 |
| Aromatics | 9 | 0.426 | 0.525 | 9 | 0.296 | 0.364 |
| Methane | 8 | 2.060 | 4.278 | 8 | 2.060 | 4.278 |
| α-Pinene | 9 | 0.635 | 0.517 | 9 | 0.441 | 0.359 |
| β-Pinene | 9 | 0.294 | 0.883 | 9 | 0.204 | 0.613 |
| d-Limonene | 9 | 0.047 | 0.142 | 9 | 0.033 | 0.099 |
| Unk #21 | 9 | 0.007 | 0.020 | 9 | 0.005 | 0.014 |
| Unk #22 | 9 | 0.010 | 0.029 | 9 | 0 | 0 |
| Unk #23 | 9 | 0.224 | 0.673 | 9 | 0.157 | 0.470 |
| Unk #27 | 9 | 0.119 | 0.317 | 9 | 0.082 | 0.220 |
| Unk #28 | 9 | 0.254 | 0.363 | 9 | 0.176 | 0.252 |
| $\Delta^3$-Carene | 9 | 0.109 | 0.294 | 9 | 0.076 | 0.204 |
| Unk #26-A | 9 | 0.133 | 0.338 | 9 | 0.092 | 0.234 |
| Unk #29-A | 9 | 3.707 | 3.984 | 9 | 0.257 | 2.760 |
| Name: Elderberry 411 (μg/g/hr) | | | | | | |
| TNMHC | 5 | 4.800 | 3.062 | 5 | 3.332 | 2.125 |
| Paraffins | 5 | 2.790 | 1.243 | 5 | 1.936 | 0.864 |
| Olefins | 5 | -0.032 | 0.072 | 5 | -0.022 | 0.049 |
| Aromatics | 5 | 2.039 | 2.000 | 5 | 1.416 | 1.387 |
| Methane | 5 | 6.352 | 11.619 | 5 | 6.352 | 11.619 |
| Name: Groundsel Bush 431 (μg/g/hr) | | | | | | |
| TNMHC | 2 | 2.540 | 1.414 | 2 | 1.765 | 0.983 |
| Paraffins | 2 | 0.564 | 0.352 | 2 | 0.392 | 0.245 |
| Olefins | 2 | 1.700 | 0.792 | 2 | 1.180 | 0.552 |
| Aromatics | 2 | 0.276 | 0.271 | 2 | 0.191 | 0.188 |
| Methane | 0 | --- | --- | 0 | --- | --- |
| α-Pinene | 2 | 1.131 | 0.564 | 2 | 0.789 | 0.397 |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Persimmon 441 (μg/g/hr) | | | | | | |
| TNMHC | 17 | 2.892 | 2.065 | 17 | 2.007 | 1.435 |
| Paraffins | 17 | 1.702 | 1.414 | 17 | 1.182 | 0.982 |
| Olefins | 17 | -0.025 | 0.180 | 17 | -0.018 | 0.126 |
| Aromatics | 17 | 1.217 | 0.895 | 17 | 0.846 | 0.621 |
| Methane | 17 | 0.076 | 1.001 | 17 | 0.076 | 1.001 |
| α-Pinene | 17 | -0.036 | 0.161 | 17 | -0.025 | 0.112 |
| β-Pinene | 17 | 0.003 | 0.011 | 17 | 0.002 | 0.008 |
| Name: Dahoon Holly 451 (μg/g/hr) | | | | | | |
| TNMHC | 3 | 2.750 | 1.401 | 3 | 1.911 | 0.968 |
| Paraffins | 3 | 1.477 | 0.768 | 3 | 1.024 | 0.531 |
| Olefins | 3 | 0 | 0 | 3 | 0 | 0 |
| Aromatics | 3 | 1.278 | 0.748 | 3 | 0.886 | 0.518 |
| Methane | 2 | 0.804 | 0.057 | 2 | 0.804 | 0.057 |
| Name: Red Bay 461 (μg/g/hr) | | | | | | |
| TNMHC | 2 | 2.003 | 1.976 | 2 | 1.391 | 1.371 |
| Paraffins | 2 | 0.457 | 0.179 | 2 | 0.317 | 0.124 |
| Olefins | 2 | 1.180 | 1.669 | 2 | 0.820 | 1.160 |
| Aromatics | 2 | 0.369 | 0.131 | 2 | 0.256 | 0.091 |
| Methane | 2 | 0.066 | 0.334 | 2 | 0.066 | 0.334 |
| α-Pinene | 2 | 0.304 | 0.429 | 2 | 0.211 | 0.298 |
| β-Pinene | 2 | 0.195 | 0.275 | 2 | 0.135 | 0.191 |
| Unk #29-A | 2 | 0.575 | 0.813 | 2 | 0.400 | 0.564 |
| Name: Red Mulberry 471 (μg/g/hr) | | | | | | |
| TNMHC | 3 | 8.230 | 5.148 | 3 | 5.730 | 3.588 |
| Paraffins | 3 | 4.911 | 3.900 | 3 | 3.413 | 2.709 |
| Olefins | 3 | 1.163 | 2.164 | 3 | 0.807 | 1.502 |
| Aromatics | 3 | 2.167 | 0.598 | 3 | 1.507 | 0.417 |
| Methane | 2 | -2.200 | 1.414 | 2 | -2.200 | 1.414 |

|  | Day |  |  | Night |  |  |
|---|---|---|---|---|---|---|
| Compound | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Name: Sweet Acacia 481 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 3 | 5.850 | 3.702 | 3 | 4.063 | 2.568 |
| Paraffins | 3 | 0.576 | 0.252 | 3 | 0.400 | 0.174 |
| Olefins | 3 | 4.707 | 3.421 | 3 | 3.271 | 2.375 |
| Aromatics | 3 | 0.570 | 0.313 | 3 | 0.396 | 0.217 |
| Methane | 3 | 2.295 | 5.502 | 3 | 2.295 | 5.502 |
| α-Pinene | 3 | 3.762 | 2.781 | 3 | 2.614 | 1.931 |
| β-Pinene | 3 | 0.414 | 0.391 | 3 | 0.288 | 0.271 |
| d-Limonene | 3 | 0.201 | 0.182 | 3 | 0.140 | 0.126 |
| Myrcene | 3 | 0.093 | 0.161 | 3 | 0.064 | 0.111 |
| Unk #21 | 3 | 0.180 | 0.312 | 3 | 0.125 | 0.217 |
| Name: Viburnum 491 (μg/g/hr) |  |  |  |  |  |  |
| TNMHC | 1 | 2.680 | --- | 1 | 1.860 | --- |
| Paraffins | 1 | 1.340 | --- | 1 | 0.930 | --- |
| Olefins | 1 | 0.214 | --- | 1 | 0.149 | --- |
| Aromatics | 1 | 1.120 | --- | 1 | 0.781 | --- |
| Methane | 1 | -0.100 | --- | 1 | -0.100 | --- |
| Unk #21-A | 1 | 0.221 | --- | 1 | 0.154 | --- |
| Name: Oleander 492 (g/g/hr) |  |  |  |  |  |  |
| TNMHC | 1 | 20.000 | --- | 1 | 13.900 | --- |
| Paraffins | 1 | 6.940 | --- | 1 | 4.820 | --- |
| Olefins | 0 | 0 | --- | 0 | 0 | --- |
| Aromatics | 1 | 13.200 | --- | 1 | 9.160 | --- |
| Methane | 1 | 1.450 | --- | 1 | 1.450 | --- |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Oranges 501 (μg/g/hr) | | | | | | |
| TNMHC | 29 | 9.334 | 15.442 | 29 | 6.484 | 10.722 |
| Paraffins | 29 | 1.857 | 2.094 | 29 | 1.288 | 1.451 |
| Olefins | 29 | 5.540 | 13.981 | 29 | 3.848 | 9.711 |
| Aromatics | 29 | 1.949 | 1.744 | 29 | 1.353 | 1.211 |
| Methane | 26 | 6.407 | 12.151 | 26 | 6.407 | 12.151 |
| d-Limonene | 29 | 0.187 | 0.572 | 29 | 0.130 | 0.397 |
| Unk #21 | 29 | 0.044 | 0.178 | 29 | 0.030 | 0.123 |
| Unk #22 | 29 | 0.404 | 0.857 | 29 | 0.281 | 0.595 |
| Unk #24 | 29 | 5.065 | 13.217 | 29 | 3.517 | 9.178 |
| Name: Grapefruit 511 (μg/g/hr) | | | | | | |
| TNMHC | 16 | 4.274 | 3.680 | 16 | 2.963 | 2.544 |
| Paraffins | 16 | 2.077 | 2.047 | 16 | 1.442 | 1.420 |
| Olefins | 16 | 0.628 | 1.603 | 16 | 0.437 | 1.113 |
| Aromatics | 16 | 1.568 | 1.464 | 16 | 1.089 | 1.017 |
| Methane | 14 | 7.238 | 10.010 | 14 | 7.238 | 10.010 |
| α-Pinene | 16 | 0.475 | 1.262 | 16 | 0.330 | 0.877 |
| Unk #16 | 16 | 0.068 | 0.270 | 16 | 0.047 | 0.188 |
| Unk #21 | 16 | 0.014 | 0.055 | 16 | 0.010 | 0.038 |
| Unk #24 | 16 | 0.005 | 0.022 | 16 | 0.004 | 0.015 |
| Unk #25 | 16 | 0.378 | 1.513 | 16 | 0.263 | 1.050 |
| Unk #26 | 16 | 0.096 | 0.383 | 16 | 0.066 | 0.265 |
| $\Delta^3$-Carene | 16 | 0.003 | 0.012 | 16 | 0.002 | 0.099 |
| Name: Australian Pine 601 (μg/g/hr) | | | | | | |
| TNMHC | 1 | 10.200 | --- | 1 | 0.625 | --- |
| Paraffins | 1 | 0.599 | --- | 1 | 0.416 | --- |
| Olefins | 1 | 9.380 | --- | 1 | 0.083 | --- |
| Aromatics | 1 | 0.162 | --- | 1 | 0.113 | --- |
| Methane | 1 | 0.579 | --- | 1 | 0.579 | --- |
| Isoprene | 1 | 9.260 | --- | 1 | 0 | --- |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Name: Sweetgum 611 (μg/g hr) | | | | | | |
| TNMHC | 17 | 60.852 | 99.553 | 17 | 35.822 | 69.175 |
| Paraffins | 17 | 3.046 | 3.549 | 17 | 2.116 | 2.472 |
| Olefins | 17 | 54.908 | 95.292 | 17 | 31.812 | 65.481 |
| Aromatics | 17 | 3.423 | 4.791 | 17 | 2.372 | 3.323 |
| Methane | 16 | -0.082 | 1.040 | 16 | -0.082 | 1.040 |
| α-Pinene | 18 | -1.366 | 31.837 | 18 | -0.934 | 22.062 |
| β-Pinene | 18 | -0.377 | 2.423 | 18 | -0.262 | 1.682 |
| d-Limonene | 18 | 1.219 | 2.427 | 18 | 0.847 | 1.686 |
| Isoprene | 18 | 8.463 | 10.237 | 18 | 0 | 0 |
| Myrcene | 18 | 2.461 | 10.442 | 18 | 1.711 | 7.260 |
| Unk Terp. | 18 | -1.889 | 8.014 | 18 | -1.278 | 5.421 |
| Unk #21 | 18 | 22.189 | 81.165 | 18 | 14.933 | 57.500 |
| $\Delta^3$-Carene | 18 | 4.290 | 13.408 | 18 | 2.978 | 9.318 |
| Unk #26-A | 18 | 3.283 | 15.438 | 18 | 2.278 | 10.704 |
| Name: American Elm 621 (μg/g hr) | | | | | | |
| TNMHC | 1 | 3.920 | --- | 1 | 2.720 | --- |
| Paraffins | 1 | 1.960 | --- | 1 | 1.360 | --- |
| Olefins | 1 | 0 | --- | 1 | 0 | --- |
| Aromatics | 1 | 1.960 | --- | 1 | 1.360 | --- |
| Methane | 1 | 0.016 | --- | 1 | 0.016 | --- |
| Name: Carolina Ash 631 (μg/g hr) | | | | | | |
| TNMHC | 1 | 0.546 | --- | 1 | 0.379 | --- |
| Paraffins | 1 | 0.173 | --- | 1 | 0.120 | --- |
| Olefins | 1 | 0 | --- | 1 | 0 | --- |
| Aromatics | 1 | 0.374 | --- | 1 | 0.260 | --- |
| Methane | 1 | 2.590 | --- | 1 | 2.590 | --- |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Name: Willow 641 (μg/g/hr) | | | | | | |
| TNMHC | 7 | 22.143 | 12.440 | 8 | 4.944 | 5.484 |
| Paraffins | 7 | 4.776 | 5.601 | 8 | 2.911 | 3.766 |
| Olefins | 7 | 14.326 | 9.727 | 8 | 0.096 | 0.132 |
| Aromatics | 7 | 3.056 | 2.808 | 8 | 1.938 | 1.882 |
| Methane | 7 | 4.801 | 6.015 | 8 | 4.076 | 5.934 |
| Isoprene | 8 | 12.399 | 10.338 | 9 | 0 | 0 |
| Name: Red Maple 651 (μg/g/hr) | | | | | | |
| TNMHC | 9 | 6.457 | 4.097 | 9 | 4.486 | 2.848 |
| Paraffins | 9 | 0.883 | 0.800 | 9 | 0.613 | 0.556 |
| Olefins | 9 | 3.473 | 3.542 | 9 | 2.411 | 2.600 |
| Aromatics | 9 | 2.104 | 1.533 | 9 | 1.461 | 1.065 |
| Methane | 9 | 2.998 | 3.197 | 9 | 2.998 | 3.197 |
| α-Pinene | 9 | 0.033 | 0.100 | 9 | 0.023 | 0.069 |
| Unk #21 | 9 | 2.267 | 2.774 | 9 | 1.574 | 1.927 |
| $\Delta^3$-Carene | 9 | 0.458 | 0.911 | 9 | 0.317 | 0.631 |
| Name: Hickory 671 (μg/g/hr) | | | | | | |
| TNMHC | 4 | 3.188 | 2.142 | 4 | 2.213 | 1.486 |
| Paraffins | 4 | 1.548 | 1.407 | 4 | 1.074 | 0.974 |
| Olefins | 4 | -0.375 | 0.750 | 4 | -0.250 | 0.500 |
| Aromatics | 4 | 2.015 | 1.040 | 4 | 1.398 | 0.721 |
| Methane | 4 | 9.346 | 18.843 | 4 | 9.346 | 18.843 |
| α-Pinene | 4 | -0.575 | 1.150 | 4 | -0.400 | 0.800 |
| β-Pinene | 4 | -0.078 | 0.155 | 4 | -0.055 | 0.110 |
| d-Limonene | 4 | 0.255 | 0.510 | 4 | 0.177 | 0.354 |
| Unk #22 | 4 | 0.112 | 0.137 | 4 | 0.078 | 0.095 |
| $\Delta^3$-Carene | 4 | 0.640 | 0.128 | 4 | 0.045 | 0.089 |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Name: Mixed Grass 700 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 24 | 190.050 | 237.128 | 24 | 190.050 | 237.128 |
| Paraffins | 24 | 75.254 | 49.203 | 24 | 75.254 | 49.203 |
| Olefins | 24 | 71.671 | 212.237 | 24 | 71.671 | 212.237 |
| Aromatics | 24 | 43.154 | 34.335 | 24 | 43.154 | 34.335 |
| Methane | 24 | 292.450 | 205.674 | 24 | 292.450 | 205.674 |
| α-Pinene | 24 | 56.198 | 161.256 | 24 | 56.198 | 161.256 |
| β-Pinene | 24 | 8.674 | 30.250 | 24 | 8.674 | 30.250 |
| d-Limonene | 24 | 0.104 | 5.993 | 24 | 0.104 | 5.993 |
| Unk Terp. | 24 | 1.008 | 4.940 | 24 | 1.008 | 4.940 |
| Unk #24 | 24 | 2.246 | 11.002 | 24 | 2.246 | 11.002 |
| $\Delta^3$-Carene | 24 | 1.649 | 5.145 | 24 | 1.649 | 5.145 |
| Name: Bahia 701 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 4 | 53.650 | 9.863 | 4 | 53.650 | 9.863 |
| Paraffins | 4 | 24.875 | 7.999 | 4 | 24.875 | 7.999 |
| Olefins | 4 | 0 | 0 | 4 | 0 | 0 |
| Aromatics | 4 | 28.775 | 13.470 | 4 | 28.775 | 13.470 |
| Methane | 4 | 147.000 | 61.395 | 4 | 147.000 | 61.395 |
| Name: Bermuda 711 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 4 | 163.250 | 40.302 | 4 | 163.250 | 40.302 |
| Paraffins | 4 | 68.525 | 45.856 | 4 | 68.525 | 45.856 |
| Olefins | 4 | 19.000 | 41.608 | 4 | 19.000 | 41.608 |
| Aromatics | 4 | 75.800 | 34.466 | 4 | 75.800 | 34.466 |
| Methane | 4 | 207.425 | 261.388 | 4 | 207.425 | 261.388 |
| α-Pinene | 4 | 3.215 | 6.250 | 4 | 3.215 | 6.250 |
| $\Delta^3$-Carene | 4 | 10.625 | 21.250 | 4 | 10.625 | 21.250 |

|  | Day |  |  | Night |  |  |
|---|---|---|---|---|---|---|
| Compound | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Name: Clover 721 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 3 | 153.00 | 14.107 | 3 | 153.00 | 14.107 |
| Paraffins | 3 | 97.467 | 11.707 | 3 | 97.467 | 11.707 |
| Olefins | 3 | 11.573 | 5.368 | 3 | 11.573 | 5.368 |
| Aromatics | 3 | 44.400 | 6.636 | 3 | 44.400 | 6.636 |
| Methane | 3 | 150.633 | 66.821 | 3 | 150.633 | 66.821 |
| Name: Pensicola 731 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 59 | 144.336 | 91.039 | 59 | 144.336 | 91.039 |
| Paraffins | 59 | 79.490 | 47.513 | 59 | 79.490 | 47.513 |
| Olefins | 59 | 13.190 | 65.896 | 59 | 13.190 | 65.896 |
| Aromatics | 59 | 51.678 | 23.986 | 59 | 51.678 | 23.986 |
| Methane | 59 | 280.831 | 175.591 | 59 | 280.831 | 175.591 |
| α-Pinene | 59 | 10.050 | 58.437 | 59 | 10.050 | 58.437 |
| β-Pinene | 59 | 2.448 | 10.314 | 59 | 2.448 | 10.314 |
| Name: Sawgrass 741 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 6 | 391.717 | 476.865 | 6 | 391.717 | 476.865 |
| Paraffins | 6 | 70.383 | 18.578 | 6 | 70.383 | 18.578 |
| Olefins | 6 | 292.500 | 456.430 | 6 | 292.500 | 456.430 |
| Aromatics | 6 | 28.505 | 11.720 | 6 | 28.505 | 11.720 |
| Methane | 6 | 313.200 | 215.211 | 6 | 313.200 | 215.211 |
| α-Pinene | 6 | 242.333 | 378.023 | 6 | 242.333 | 378.023 |
| β-Pinene | 6 | 39.167 | 61.568 | 6 | 39.167 | 61.568 |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Tomatoes 801 (μg/g/hr) | | | | | | |
| TNMHC | 6 | 48.083 | 24.619 | 6 | 33.400 | 17.081 |
| Paraffins | 6 | 7.555 | 5.648 | 6 | 5.243 | 3.910 |
| Olefins | 6 | 31.355 | 19.473 | 6 | 21.745 | 13.508 |
| Aromatics | 6 | 9.278 | 13.152 | 6 | 6.443 | 9.133 |
| Methane | 7 | 4.127 | 15.142 | 7 | 4.127 | 15.141 |
| d-Limonene | 7 | 15.301 | 11.865 | 7 | 10.636 | 8.247 |
| Myrcene | 7 | 0.129 | 0.341 | 7 | 0.900 | 0.2370 |
| Unk #21 | 7 | 5.543 | 4.445 | 7 | 3.850 | 3.087 |
| Unk #23 | 7 | 1.207 | 1.121 | 7 | 0.840 | 0.7793 |
| $\Delta^3$-Carene | 7 | 3.930 | 2.820 | 7 | 2.728 | 1.960 |
| Name: Strawberries 811 (μg/m$^2$/hr) | | | | | | |
| TNMHC | 2 | 419.000 | 420.021 | 2 | 290.800 | 291.611 |
| Paraffins | 2 | 360.55 | 406.516 | 2 | 250.400 | 282.277 |
| Olefins | 2 | 0 | 0 | 2 | 0 | 0 |
| Aromatics | 2 | 58.350 | 13.647 | 2 | 40.550 | 9.405 |
| Methane | 2 | 174.000 | 83.439 | 2 | 174.000 | 83.439 |
| Name: Beans 821 (μg/m$^2$/hr) | | | | | | |
| TNMHC | 10 | 1565.100 | 1053.640 | 10 | 264.390 | 182.476 |
| Paraffins | 10 | 296.700 | 220.010 | 10 | 205.970 | 152.631 |
| Olefins | 10 | 1172.800 | 850.750 | 10 | -8.690 | 23.668 |
| Aromatics | 10 | 95.420 | 44.720 | 10 | 66.300 | 31.083 |
| Methane | 8 | 669.880 | 36.470 | 8 | 669.875 | 36.471 |
| Isoprene | 10 | 1184.100 | 835.440 | 10 | 0 | 0 |
| Name: Okra 841 (μg/g/hr) | | | | | | |
| TNMHC | 6 | 9.847 | 11.495 | 6 | 6.840 | 7.979 |
| Paraffins | 6 | 5.593 | 6.664 | 6 | 3.886 | 4.630 |
| Olefins | 6 | 0 | 0 | 6 | 0 | 0 |
| Aromatics | 6 | 4.250 | 4.979 | 6 | 2.953 | 3.463 |
| Methane | 6 | 0.849 | 2.427 | 6 | 0.849 | 2.427 |

|  | Day |  |  | Night |  |  |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Grassy Mudflat (Marine) 0"-2" Water 901 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 7 | 206.371 | 250.511 | 7 | 206.371 | 250.511 |
| Paraffins | 7 | 148.443 | 208.617 | 7 | 148.443 | 208.617 |
| Olefins | 7 | 0 | 0 | 7 | 0 | 0 |
| Aromatics | 7 | 57.943 | 44.785 | 7 | 57.943 | 44.785 |
| Methane | 7 | 352.429 | 178.100 | 7 | 352.429 | 178.100 |
| Name: Grassy Mudflat (2"-12") 902 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 11 | 77.927 | 39.459 | 11 | 77.927 | 39.459 |
| Paraffins | 11 | 36.855 | 13.310 | 11 | 36.855 | 13.310 |
| Olefins | 11 | 0 | 0 | 11 | 0 | 0 |
| Aromatics | 11 | 41.091 | 29.167 | 11 | 41.091 | 29.167 |
| Methane | 11 | 186.200 | 107.170 | 11 | 186.200 | 107.170 |
| Name: Grassy Mudflat (12"-2') 903 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 4 | 79.300 | 39.125 | 4 | 79.300 | 39.125 |
| Paraffins | 4 | 45.050 | 22.000 | 4 | 45.050 | 22.000 |
| Olefins | 4 | 0 | 0 | 4 | 0 | 0 |
| Aromatics | 4 | 34.325 | 18.421 | 4 | 34.325 | 18.421 |
| Methane | 4 | 143.250 | 18.283 | 4 | 143.250 | 18.283 |
| Name: Grassy Mudflat (2'-5') 904 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 10 | 123.650 | 57.479 | 10 | 123.650 | 57.479 |
| Paraffins | 10 | 69.130 | 46.001 | 10 | 69.130 | 46.001 |
| Olefins | 10 | 0 | 0 | 10 | 0 | 0 |
| Aromatics | 10 | 54.610 | 22.180 | 10 | 54.610 | 22.180 |
| Methane | 10 | 201.110 | 225.747 | 10 | 201.110 | 225.747 |
| Name: Sandy Bottom (>5') 905 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 15 | 89.540 | 50.143 | 15 | 89.540 | 50.143 |
| Paraffins | 15 | 50.153 | 33.033 | 15 | 50.153 | 33.033 |
| Olefins | 15 | 0 | 0 | 15 | 0 | 0 |
| Aromatics | 15 | 39.329 | 21.175 | 15 | 39.329 | 21.175 |
| Methane | 15 | 281.200 | 284.621 | 15 | 281.200 | 284.621 |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Decaying Marine Algae 911 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 2 | 209.500 | 126.572 | 2 | 209.500 | 126.572 |
| Paraffins | 2 | 50.800 | 29.557 | 2 | 50.800 | 29.557 |
| Olefins | 2 | 127.500 | 180.312 | 2 | 127.500 | 180.312 |
| Aromatics | 2 | 31.400 | 23.193 | 2 | 31.400 | 23.193 |
| Methane | 2 | 433.000 | 69.296 | 2 | 433.000 | 69.296 |
| α-Pinene | 2 | 32.650 | 46.174 | 2 | 32.650 | 46.174 |
| Myrcene | 2 | 31.000 | 43.841 | 2 | 31.000 | 43.841 |
| Terpinolene | 2 | 31.000 | 43.841 | 2 | 31.000 | 43.841 |
| Name: Decaying Marine Grass 912 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 5 | 87.200 | 20.027 | 5 | 87.200 | 20.027 |
| Paraffins | 5 | 54.520 | 19.467 | 5 | 54.520 | 19.467 |
| Olefins | 5 | 0 | 0 | 5 | 0 | 0 |
| Aromatics | 5 | 32.720 | 12.138 | 5 | 32.720 | 12.138 |
| Methane | 4 | 375.750 | 136.170 | 4 | 375.750 | 136.170 |
| Name: Decaying Mixed Vegetation 913 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 11 | 96.100 | 15.056 | 11 | 96.100 | 49.935 |
| Paraffins | 11 | 49.700 | 5.721 | 11 | 49.700 | 18.973 |
| Olefins | 11 | 0 | 0 | 11 | 0 | 0 |
| Aromatics | 11 | 46.373 | 10.655 | 11 | 46.373 | 35.338 |
| Methane | 10 | 380.300 | 72.605 | 10 | 380.300 | 229.598 |
| Name: Mudflat No Grass 0-2" $H_2O$ 921 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 1 | 215.000 | --- | 1 | 215.000 | --- |
| Paraffins | 1 | 119.000 | --- | 1 | 119.000 | --- |
| Olefins | 1 | 0 | --- | 1 | 0 | --- |
| Aromatics | 1 | 96.900 | --- | 1 | 96.900 | --- |
| Methane | 1 | 80.800 | --- | 1 | 80.800 | --- |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Mudflat 2"-12" 922 (μg/m$^2$/hr) | | | | | | |
| TNMHC | 4 | 85.575 | 11.481 | 4 | 85.575 | 11.481 |
| Paraffins | 4 | 43.050 | 10.573 | 4 | 43.050 | 10.573 |
| Olefins | 4 | 0 | 0 | 4 | 0 | 0 |
| Aromatics | 4 | 42.500 | 6.472 | 4 | 42.500 | 6.472 |
| Methane | 4 | 151.475 | 58.066 | 4 | 151.475 | 58.066 |
| Name: Mudflat 12"-2' 923 (μg/m$^2$/hr) | | | | | | |
| TNMHC | 2 | 105.550 | 812.470 | 2 | 105.550 | 812.470 |
| Paraffins | 2 | 66.250 | 56.215 | 2 | 66.250 | 56.215 |
| Olefins | 2 | 0 | 0 | 2 | 0 | 0 |
| Aromatics | 2 | 39.300 | 25.032 | 2 | 39.300 | 25.032 |
| Methane | 2 | 124.750 | 59.751 | 2 | 124.750 | 59.751 |
| Name: Mudflat 2'-5' 924 (μg/m$^2$/hr) | | | | | | |
| TNMHC | 22 | 136.582 | 125.379 | 22 | 136.582 | 125.379 |
| Paraffins | 22 | 79.746 | 72.120 | 22 | 79.746 | 72.120 |
| Olefins | 22 | 0 | 0 | 22 | 0 | 0 |
| Aromatics | 22 | 56.900 | 55.955 | 22 | 56.900 | 55.955 |
| Methane | 22 | 271.973 | 219.996 | 22 | 271.973 | 219.996 |
| Unk #10-A | 23 | 1.339 | 6.422 | 23 | 1.339 | 6.422 |
| Unk #22 | 23 | 0.373 | 1.787 | 23 | 0.373 | 1.787 |
| Name: Mudflat >5' 925 (μg/m$^2$/hr) | | | | | | |
| TNMHC | 48 | 149.423 | 141.883 | 48 | 149.423 | 141.883 |
| Paraffins | 48 | 79.179 | 73.237 | 48 | 79.179 | 73.237 |
| Olefins | 48 | 0 | 0 | 48 | 0 | 0 |
| Aromatics | 48 | 70.279 | 75.114 | 48 | 70.279 | 75.114 |
| Methane | 48 | 305.417 | 247.450 | 48 | 305.417 | 247.450 |
| Unk #10-A | 48 | 4.063 | 28.146 | 48 | 4.063 | 28.146 |
| Unk #22 | 48 | 1.412 | 9.786 | 48 | 1.412 | 9.786 |
| Unk #23 | 48 | 0.005 | 0.032 | 48 | 0.005 | 0.032 |
| Unk #24 | 48 | 0.444 | 3.074 | 48 | 0.444 | 3.074 |

| | Day | | | Night | | |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Sandy Beach 931 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 1 | 349.000 | --- | 1 | 349.000 | --- |
| Paraffins | 1 | 157.000 | --- | 1 | 157.000 | --- |
| Olefins | 1 | 0 | --- | 1 | 0 | --- |
| Aromatics | 1 | 192.000 | --- | 1 | 192.000 | --- |
| Methane | 1 | 380.000 | --- | 1 | 380.000 | --- |
| Name: Fresh $H_2O$ Marsh (o"-2") 941 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 4 | 74.670 | 23.900 | 4 | 74.670 | 23.900 |
| Paraffins | 4 | 49.870 | 23.860 | 4 | 49.870 | 23.860 |
| Olefins | 4 | 0 | 0 | 4 | 0 | 0 |
| Aromatics | 4 | 24.820 | 1.310 | 4 | 24.820 | 1.310 |
| Methane | 3 | 2940.330 | 2456.340 | 3 | 2940.330 | 2456.340 |
| Unk. #17 | 4 | -0.650 | 1.300 | | -0.650 | 1.300 |
| Unk. #18 | 4 | 1.850 | 3.690 | | 1.850 | 3.690 |
| Name: Fresh Water Marsh (>12") 942 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 3 | 120.100 | 44.950 | 3 | 120.100 | 44.950 |
| Paraffins | 3 | 48.530 | 14.180 | 3 | 48.530 | 14.180 |
| Olefins | 3 | 0 | 0 | 3 | 0 | 0 |
| Aromatics | 3 | 71.430 | 44.440 | 3 | 71.430 | 44.440 |
| Methane | 3 | 1432.330 | 1811.420 | 3 | 1432.330 | 1811.420 |
| Name: Fresh Water Marsh (hyacinth) 943 ($\mu g/m^2/hr$) | | | | | | |
| TNMHC | 2 | 69.650 | 8.410 | 2 | 69.650 | 8.410 |
| Paraffins | 2 | 26.850 | 15.490 | 2 | 26.850 | 15.490 |
| Olefins | 2 | 0 | 0 | 2 | 0 | 0 |
| Aromatics | 2 | 42.800 | 7.070 | 2 | 42.800 | 7.070 |
| Methane | 2 | 1792.500 | 1269.260 | 2 | 1792.500 | 1269.260 |

|  |  | Day |  |  | Night |  |
|---|---|---|---|---|---|---|
| Compound | N | $\overline{X}$ | SD | N | $\overline{X}$ | SD |
| Name: Fresh Water Marsh (Waterlilly) 944 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 2 | 164.000 | 15.600 | 2 | 164.000 | 15.600 |
| Paraffins | 2 | 94.600 | 14.600 | 2 | 94.600 | 14.600 |
| Olefins | 2 | 0 | 0 | 2 | 0 | 0 |
| Aromatics | 2 | 69.500 | 0.800 | 2 | 69.500 | 0.800 |
| Methane | 2 | 36950.000 | 29769.200 | 2 | 36950.000 | 29769.200 |
| Name: Oyster Beds 950 ($\mu g/m^2/hr$) |  |  |  |  |  |  |
| TNMHC | 1 | 50.400 | --- | 1 | 50.400 | --- |
| Paraffins | 1 | 32.800 | --- | 1 | 32.800 | --- |
| Olefins | 1 | 0 | --- | 1 | 0 | --- |
| Aromatics | 1 | 17.600 | --- | 1 | 17.600 | --- |
| Methane | 1 | 323.000 | --- | 1 | 323.000 | --- |

## APPENDIX B

### INTRODUCTION

This appendix contains the emission factors (ER) and variances ($S^2$) for each vegetation association during a 30°C day and a 25°C night. $S^2$ was calculated by multiplying the variance of each species/sample type times the square of its association multiplication factor and summing these for each association. This procedure carries the implicit assumption that the mean emission rates in Appendix A are independently related.

Since a change in one species/sample type emission rate value in Appendix A will not affect the emission rates of any of the other species/sample types, this assumption seems valid. The "name" designates the computer letter code and the association type. All emission factors are in micrograms per meter squared ground surface per hour ($\mu g/m^2/hr$).

## APPENDIX B

### Association Emission Factors ($\mu g/m^2/hr$)

| Compound | Day | | Night | |
|---|---|---|---|---|
| | ER | $S^2$ | ER | $S^2$ |
| Name: | Assn. A Mangrove | | | |
| TNMHC | 765.266 | 150551.0 | 561.323 | 73002.6 |
| Paraffins | 439.131 | 83182.7 | 321.487 | 40567.2 |
| Olefins | 3.109 | 118.9 | 2.180 | 57.4 |
| Aromatics | 323.738 | 38429.5 | 238.036 | 18563.0 |
| Methane | 1017.190 | 600835.0 | 1017.190 | 600835.0 |
| Name: | Assn. B Pine | | | |
| TNMHC | 4289.950 | 8287360.0 | 2364.540 | 3499180.0 |
| Paraffins | 602.553 | 104704.0 | 434.125 | 50472.7 |
| Olefins | 3276.390 | 7303520.0 | 1638.970 | 3188770.0 |
| Aromatics | 372.757 | 33513.0 | 265.746 | 166333.2 |
| Methane | 821.851 | 190969.0 | 810.816 | 190278.0 |
| α-Pinene | 857.510 | 1196080.0 | 612.619 | 590904.0 |
| β-Pinene | 877.476 | 1694520.0 | 611.880 | 817258.0 |
| d-Limonene | 113.827 | 22492.5 | 79.075 | 10847.7 |
| Isoprene | 946.987 | 675435.0 | 0.000 | 0.0 |
| Myrcene | 0.158 | 0.720 | 0.110 | 0.349 |
| Unk. Terpenes | 1.008 | 24.4 | 1.008 | 24.4 |
| 21A | 7.322 | 0.0 | 5.102 | 0.0 |
| 18 | 0.452 | 7.165 | 0.306 | 3.361 |
| 20 | 0.217 | 1.644 | 0.146 | 0.771 |
| 22 | 10.188 | 1824.2 | 6.881 | 856.8 |
| 24 | 2.246 | 121.1 | 2.246 | 121.1 |
| $\Delta^3$-Carene | 189.733 | 124492.0 | 132.201 | 60042.5 |
| Name: | Assn. C Citrus | | | |
| TNMHC | 5974.090 | 83781200.0 | 4199.180 | 40399500.0 |
| Paraffins | 1317.130 | 1558510.0 | 938.209 | 748416.0 |
| Olefins | 3352.490 | 66638800.0 | 233.742 | 33109700.0 |
| Aromatics | 1311.640 | 63.838 | 927.057 | 519264.0 |
| Methane | 4505.220 | 52289100.0 | 4505.220 | 52289100.0 |
| α-Pinene | 48.626 | 8745.0 | 39.061 | 5168.5 |
| β-Pinene | 2.780 | 63.838 | 2.780 | 63.8 |
| d-Limonene | 111.528 | 114893.0 | 77.638 | 55394.7 |
| Myrcene | 0.750 | 2.250 | 0.750 | 2.250 |
| Unk. Terpenes | 0.252 | 1.525 | 0.252 | 1.525 |
| 16 | 4.444 | 315.9 | 3.091 | 152.8 |
| 21 | 26.808 | 11151.0 | 18.629 | 5348.9 |
| 22 | 239.299 | 257860.0 | 166.247 | 124261.0 |
| 24 | 3001.780 | 61323300.0 | 2084.520 | 29570000.0 |
| 25 | 24.890 | 9915.2 | 17.280 | 4775.6 |
| 26 | 6.295 | 634.0 | 4.361 | 304.3 |
| $\Delta^3$-Carene | 3.269 | 30.530 | 3.207 | 30.2 |

Association Emission Factors ($\mu g/m^2/hr$)

| | Day | | Night | |
|---|---|---|---|---|
| Compound | ER | $S^2$ | ER | $S^2$ |
| Name: Assn. D Oak, Gum, Cypress (Domes) | | | | |
| TNMHC | 6807.000 | 15479100.0 | 3817.460 | 7280810.0 |
| Paraffins | 993.542 | 464183.0 | 701.483 | 223343.0 |
| Olefins | 5018.710 | 14504500.0 | 2561.450 | 6758540.0 |
| Aromatics | 801.235 | 265039.0 | 560.589 | 127612.0 |
| Methane | 1341.940 | 1671330.0 | 1326.060 | 1670900.0 |
| α-Pinene | 1043.900 | 3289920.0 | 792.606 | 1641350.0 |
| β-Pinene | 36.196 | 10634.7 | 35.908 | 6716.5 |
| d-Limonene | 94.761 | 14562.2 | 65.819 | 7019.8 |
| Isoprene | 1385.170 | 593605.0 | 0.000 | 0.0 |
| Myrcene | 137.484 | 143666.0 | 95.460 | 69381.8 |
| Unk. Terpenes | -7.315 | 131337.0 | -3.972 | 61584.2 |
| 17 | -0.065 | 0.017 | -0.065 | 0.017 |
| 18 | 0.185 | 0.136 | 0.185 | 0.136 |
| 21 | 772.050 | 7219980.0 | 520.262 | 3623100.0 |
| 22 | 14.364 | 4090.2 | 9.945 | 1960.3 |
| 23 | 1.486 | 19.870 | 1.037 | 9.681 |
| 27 | 29.484 | 16475.4 | 20.406 | 7890.5 |
| 28 | 1.681 | 5.763 | 1.167 | 2.782 |
| $\Delta^3$-Carene | 708.361 | 1021560.0 | 491.185 | 493595.0 |
| 26A | 109.550 | 2610890.0 | 76.014 | 125559.0 |
| 29A | 25.392 | 701.3 | 17.552 | 336.4 |
| Name: Assn. E Oak, Gum, Cypress (Drained) | | | | |
| TNMHC | 4436.090 | 22368.0 | 2558.580 | 2857170.0 |
| Paraffins | 656.341 | 175404.0 | 470.771 | 84457.7 |
| Olefins | 3250.500 | 5566120.0 | 1714.980 | 2649760.0 |
| Aromatics | 532.140 | 100605.0 | 375.322 | 48471.1 |
| Methane | 1089.060 | 693824.0 | 1079.140 | 693653.0 |
| α-Pinene | 727.460 | 1309660.0 | 572.453 | 689577.0 |
| β-Pinene | 37.026 | 5954.3 | 36.484 | 4460.6 |
| d-Limonene | 58.308 | 5478.2 | 40.500 | 2640.8 |
| Isoprene | 858.588 | 223638.0 | 0.000 | 0.0 |
| Myrcene | 84.318 | 54037.0 | 58.545 | 26096.5 |
| Unk. Terpenes | -4.486 | 49399.6 | -2.436 | 23163.6 |
| 17 | -0.065 | 0.017 | -0.065 | 0.017 |
| 18 | 0.185 | 0.136 | 0.185 | 0.136 |
| 21 | 496.530 | 2718010.0 | 335.068 | 1363900.0 |
| 22 | 8.849 | 1538.5 | 6.127 | 737.3 |
| 23 | 1.822 | 29.9 | 1.272 | 14.6 |
| 27 | 18.565 | 6201.8 | 12.849 | 2970.2 |
| 28 | 2.062 | 8.670 | 1.432 | 4.186 |
| $\Delta^3$-Carene | 439.521 | 384498.0 | 304.762 | 185780.0 |
| 26A | 67.728 | 98208.4 | 46.994 | 47229.0 |
| 29A | 30.623 | 1048.6 | 21.207 | 503.4 |

## Association Emission Factors ($\mu g/m^2/hr$)

| Compound | Day ER | Day $S^2$ | Night ER | Night $S^2$ |
|---|---|---|---|---|
| Name: Assn. G Xeric Oak (cont'd) | | | | |
| 26A | 1.112 | 7.936 | 0.771 | 3.802 |
| 29A | 30.916 | 1103.8 | 21.450 | 530.0 |
| Name: Assn. H Hydric Oak | | | | |
| TNMHC | 7840.610 | 29779300.0 | 2766.440 | 5389160.0 |
| Paraffins | 884.093 | 423365.0 | 599.801 | 176145.0 |
| Olefins | 6134.830 | 21004600.0 | 1623.350 | 4239210.0 |
| Aromatics | 827.685 | 205562.0 | 553.785 | 90707.4 |
| Methane | 1514.730 | 454815.0 | 1415.780 | 449422.0 |
| α-Pinene | 177.712 | 992150.0 | 157.866 | 489501.0 |
| β-Pinene | 75.448 | 21159.0 | 58.636 | 10620.9 |
| d-Limonene | 64.132 | 6642.2 | 44.561 | 3212.3 |
| Isoprene | 3822.670 | 10992600.0 | 0.000 | 0.0 |
| Myrcene | 77.386 | 103022.0 | 53.798 | 49809.0 |
| Unk. Terpenes | -55.652 | 60754.9 | -37.393 | 27812.1 |
| 21 | 905.165 | 6299780.0 | 613.810 | 3159910.0 |
| 22 | 1.883 | 6.785 | 1.308 | 3.261 |
| 23 | 1.380 | 17.149 | 0.964 | 8.355 |
| 24 | 1.572 | 59.339 | 1.572 | 59.3 |
| 27 | 1.619 | 19.592 | 1.122 | 9.393 |
| 28 | 1.561 | 4.974 | 1.084 | 2.401 |
| 29 | 0.497 | 1.322 | 0.296 | 0.557 |
| $\Delta^3$-Carene | 230.902 | 183916.0 | 160.513 | 88775.7 |
| 26A | 101.740 | 225185.0 | 70.594 | 108293.0 |
| 29A | 26.598 | 625.8 | 18.437 | 300.5 |
| Name: Assn. I Representative Shrubs | | | | |
| TNMHC | 1983.460 | 454221.0 | 881.610 | 136414.0 |
| Paraffins | 487.518 | 74267.0 | 337.796 | 34446.4 |
| Olefins | 1170.920 | 290744.0 | 314.846 | 52772.5 |
| Aromatics | 324.857 | 21731.4 | 228.701 | 10227.4 |
| Methane | 724.839 | 202707.0 | 689.748 | 200567.0 |
| α-Pinene | 87.072 | 13976.4 | 73.517 | 13360.6 |
| β-Pinene | 39.497 | 3147.7 | 30.598 | 1788.3 |
| d-Limonene | 4.581 | 77.6 | 3.204 | 46.5 |
| Isoprene | 661.230 | 232071.0 | 0.000 | 0.0 |
| Myrcene | 0.003 | 0.0003 | 0.002 | 0.0001 |
| Unk. Terpenes | 0.706 | 11.956 | 0.706 | 11.956 |
| 21 | 0.334 | 1.006 | 0.232 | 0.486 |
| 22 | 0.499 | 2.238 | 0.346 | 1.075 |
| 23 | 1.144 | 1179.3 | 7.992 | 574.6 |
| 24 | 1.572 | 59.3 | 1.572 | 59.3 |
| 27 | 6.059 | 261.1 | 4.204 | 125.8 |

## Association Emission Factors ($\mu g/m^2/hr$)

| Compound | Day ER | Day $S^2$ | Night ER | Night $S^2$ |
|---|---|---|---|---|
| Name: Assn. I Representative Shrubs (cont'd) | | | | |
| 28 | 12.949 | 342.0 | 8.991 | 165.1 |
| 29 | 0.808 | 3.496 | 0.480 | 1.472 |
| $\Delta^3$-Carene | 10.180 | 279.8 | 7.421 | 141.8 |
| 26A | 6.803 | 296.8 | 4.714 | 142.2 |
| 29A | 193.329 | 41319.6 | 133.986 | 19838.0 |
| Name: Assn. J Palmetto | | | | |
| TNMHC | 5387.500 | 65180200.0 | 1106.000 | 2055920.0 |
| Paraffins | 660.250 | 913063.0 | 475.075 | 427671.0 |
| Olefins | 3971.820 | 42489000.0 | 93.207 | 48514.9 |
| Aromatics | 758.649 | 1350030.0 | 538.600 | 636016.0 |
| Methane | 1337.750 | 3723750.0 | 1308.500 | 3636670.0 |
| α-Pinene | 53.371 | 26280.1 | 54.200 | 26144.0 |
| β-Pinene | 8.674 | 915.0 | 8.674 | 915.0 |
| d-Limonene | 0.104 | 35.9 | 0.104 | 35.9 |
| Isoprene | 3867.750 | 41694700.0 | 0.000 | 0.0 |
| Unk. Terpenes | 1.008 | 24.4 | 1.008 | 24.4 |
| 18 | 6.147 | 1321.9 | 4.150 | 620.0 |
| 20 | 2.944 | 303.3 | 1.988 | 142.2 |
| 22 | 138.375 | 336555.0 | 93.465 | 158071.0 |
| 24 | 2.246 | 121.1 | 2.246 | 121.1 |
| $\Delta^3$-Carene | 1.649 | 26.5 | 1.649 | 26.5 |
| Name: Assn. K Improved Pasture | | | | |
| TNMHC | 159.505 | 4515.2 | 159.505 | 4515.2 |
| Paraffins | 73.426 | 570.9 | 73.426 | 570.9 |
| Olefins | 37.952 | 3219.2 | 37.952 | 3219.2 |
| Aromatics | 48.208 | 178.1 | 48.208 | 178.1 |
| Methane | 251.000 | 8816.4 | 251.000 | 8816.4 |
| α-Pinene | 28.190 | 2091.6 | 28.190 | 2091.6 |
| β-Pinene | 4.795 | 67.6 | 4.795 | 67.6 |
| Myrcene | 0.300 | 0.360 | 0.300 | 0.360 |
| Unk. Terpenes | 0.202 | 0.976 | 0.202 | 0.976 |
| 24 | 0.449 | 4.844 | 0.449 | 4.844 |
| $\Delta^3$-Carene | 1.392 | 5.575 | 1.392 | 5.575 |
| Name: Assn. L Unimproved Pasture | | | | |
| TNMHC | 207.605 | 20583.2 | 207.605 | 20583.2 |
| Paraffins | 70.100 | 548.3 | 70.100 | 548.3 |
| Olefins | 94.549 | 17513.4 | 94.549 | 17513.4 |
| Aromatics | 42.962 | 263.8 | 42.962 | 263.8 |
| Methane | 265.270 | 11458.9 | 265.270 | 11458.9 |
| α-Pinene | 75.068 | 11015.6 | 75.068 | 11015.6 |

### Association Emission Factors (μg/m$^2$/hr)

| | Day | | Night | |
|---|---|---|---|---|
| Compound | ER | $S^2$ | ER | $S^2$ |
| | Name: Assn. L Unimproved Pasture (cont'd) | | | |
| α-Pinene | 11.982 | 338.0 | 11.982 | 338.0 |
| β-Limonene | 0.283 | 7.495 | 0.283 | 7.495 |
| Myrcene | 0.300 | 0.360 | 0.300 | 0.360 |
| Unk. Terpenes | 0.454 | 4.941 | 0.454 | 4.941 |
| 24 | 1.011 | 24.5 | 1.011 | 24.5 |
| $\Delta^3$-Carene | 1.804 | 9.876 | 1.804 | 9.876 |
| | Name: Assn. M Crops | | | |
| TNMHC | 828.956 | 150347.0 | 287.860 | 11004.3 |
| Paraffins | 192.063 | 8731.4 | 133.360 | 4203.8 |
| Olefins | 543.474 | 95482.5 | 89.136 | 3349.5 |
| Aromatics | 93.871 | 3678.3 | 65.209 | 1774.3 |
| Methane | 272.418 | 4431.1 | 272.418 | 4431.1 |
| d-Limonene | 64.872 | 2531.2 | 45.114 | 1223.8 |
| Isoprene | 414.400 | 85504.9 | 0.000 | 0.0 |
| Myrcene | 0.547 | 2.1 | 0.380 | 1.0 |
| 21 | 23.502 | 355.2 | 16.324 | 171.3 |
| 23 | 5.118 | 22.6 | 3.560 | 10.9 |
| $\Delta^3$-Carene | 16.663 | 143.0 | 11.567 | 69.1 |

# APPENDIX C

## LUDA EMISSION FACTORS

This appendix contains the day and night LUDA emission factors in $\mu g/m^2/hr$. LUDA (Land Use and Land Cover Data Analysis System) map identification codes and their general designations are given in the headings.

The variance ($S^2$) was calculated for each LUDA category from the variance for each species times the square of the multiplication factor summed for all species in each LUDA category, plus the variance for each association times the square of the association percent in each LUDA category, summed for all associations in the LUDA category. Symbolically, this appears as:

$$S^2 \text{ LUDA} = [S_1^2(f_1^2) + S_2^2(f_2^2). \ . \ . \ . \ . + S_n^2(f_n^2)] \ = [S_a^2(f_n^2) + S_b^2(f_b^2) + S_n^2(f_n^2)]$$

where: $S_1^2(f_1^2)$ represents species variance times its squared multiplication factor. $S_a^2(f_a^2)$ represents the association variance times its squared multiplication factor. This calculation procedure assumes that all values are independent. However, it is recognized that since many associations share some species, the variances show a slight positive correlation. The correlation coefficients vary between each association depending upon the number of species shared, the predominance of the shared species in each association, and the predominance of each association in each LUDA category. The detailed statistical analysis and computer programming that would be required to evaluate the LUDA variances more accurately were beyond the scope of this project.

It should also be noted that the variances reported here can only be considered as rough estimates of the variance associated with the samples involved in the LUDA emission estimates. However, uncertainties in emission rate algorithms, temperature regimes, annual emission rate variability and many other unknown factors which may cause actual emissions to vary from the emission estimates reported here make a more detailed analysis of the sample variances superfluous.

## APPENDIX C

### LUDA Emission Factors
$\mu g/m^2/hr$

| | Day | | Night | |
|---|---|---|---|---|
| Compound | ER | $s^2$ | ER | $s^2$ |
| Name: | LUDA 0011 | Residential | | |
| TNMHC | 2006.520 | 122974.0 | 878.956 | 32111.4 |
| Paraffins | 393.924 | 4680.2 | 279.014 | 2214.9 |
| Olefins | 119.772 | 101638.0 | 306.961 | 25277.4 |
| Aromatics | 412.204 | 1365.8 | 291.497 | 666.6 |
| Methane | 378.625 | 17725.0 | 367.795 | 1750.3 |
| α-Pinene | 163.826 | 10290.0 | 120.265 | 5431.7 |
| β-Pinene | 112.851 | 11526.2 | 80.900 | 5619.8 |
| d-Limonene | 14.538 | 158.4 | 10.104 | 76.9 |
| Isoprene | 753.571 | 52072.7 | 0.000 | 0.0 |
| Myrcene | 1.317 | 5.083 | 0.914 | 2.450 |
| Unk. Terpenes | 0.302 | 0.790 | 0.302 | 0.790 |
| 21A | 3.865 | 0.0 | 2.693 | 0.0 |
| 18 | 0.041 | 0.046 | 0.028 | 0.022 |
| 20 | 0.020 | 0.011 | 0.013 | 0.005 |
| 21 | 2.603 | 19.271 | 1.809 | 9.310 |
| 22 | 1.023 | 11.195 | 0.693 | 5.613 |
| 23 | 2.439 | 47.374 | 1.703 | 23.1 |
| 24 | 0.674 | 3.924 | 0.674 | 3.924 |
| 27 | 1.291 | 10.049 | 0.896 | 5.053 |
| 28 | 2.759 | 13.740 | 1.916 | 6.633 |
| 29 | 1.051 | 4.377 | 0.625 | 1.843 |
| $\Delta^3$-Carene | 20.165 | 83.458 | 14.149 | 402.9 |
| 26A | 11.450 | 1.922 | 1.004 | 5.712 |
| 29A | 41.139 | 1659.8 | 28.513 | 796.9 |
| Name: | LUDA 0021 | Cropland Pasture | | |
| TNMHC | 518.281 | 42733. | 247.732 | 7896.8 |
| Paraffins | 131.081 | 23230. | 101.730 | 1188.0 |
| Olefins | 319.011 | 28249. | 91.842 | 5215.7 |
| Aromatics | 68.417 | 985.5 | 54.086 | 509.5 |
| Methane | 268.884 | 3973. | 268.844 | 3972.5 |
| α-Pinene | 37.534 | 2753.9 | 37.534 | 2753.9 |
| β-Pinene | 5.992 | 84.5 | 5.991 | 84.5 |
| d-Limonene | 32.578 | 634.7 | 22.698 | 307.6 |
| Isoprene | 207.200 | 21376.2 | 0.000 | 0.0 |
| Myrcene | 0.423 | 0.614 | 0.340 | 0.342 |
| Unk. Terpenes | 0.227 | 1.235 | 0.227 | 1.235 |
| 21 | 11.751 | 88.8 | 8.162 | 42.8 |
| 23 | 2.559 | 5.649 | 1.780 | 2.729 |
| 24 | 0.505 | 6.131 | 0.505 | 6.131 |
| $\Delta^3$-Carene | 9.234 | 38.2 | 6.685 | 19.7 |

## LUDA Emission Factors
$\mu g/m^2/hr$

| Compound | Day | | Night | |
|---|---|---|---|---|
| | ER | $S^2$ | ER | $S^2$ |
| Name: LUDA 0022 Orchards, Vineyards, Nurseries | | | | |
| TNMHC | 2006.520 | 122974.0 | 878.956 | 32111.4 |
| Paraffins | 393.924 | 4680.2 | 279.014 | 2214.9 |
| Olefins | 119.772 | 101638.0 | 306.961 | 25277.4 |
| Aromatics | 412.204 | 1365.8 | 291.497 | 666.6 |
| Methane | 378.625 | 17725.0 | 367.795 | 17502.8 |
| α-Pinene | 163.826 | 10290.0 | 120.265 | 5431.7 |
| β-Pinene | 112.851 | 11526.2 | 80.900 | 5619.8 |
| d-Limonene | 14.538 | 158.4 | 10.104 | 76.9 |
| Isoprene | 753.571 | 52072.7 | 0.000 | 0.0 |
| Myrcene | 1.317 | 5.083 | 0.914 | 2.450 |
| Unk. Terpenes | 0.302 | 0.790 | 0.302 | 0.790 |
| 21A | 3.865 | 0.0 | 2.694 | 0.0 |
| 18 | 0.041 | 0.047 | 0.028 | 0.022 |
| 20 | 0.020 | 0.011 | 0.013 | 0.005 |
| 21 | 2.063 | 19.271 | 1.809 | 9.310 |
| 22 | 1.024 | 11.950 | 0.693 | 5.613 |
| 23 | 2.439 | 47.374 | 1.703 | 23.1 |
| 24 | 0.674 | 3.924 | 0.674 | 3.924 |
| 27 | 1.291 | 1.049 | 0.896 | 5.053 |
| 28 | 2.579 | 13.740 | 1.916 | 6.633 |
| 29 | 1.050 | 4.377 | 0.625 | 1.843 |
| $\Delta^3$-Carene | 20.165 | 834.6 | 14.149 | 402.9 |
| 26A | 1.450 | 11.922 | 1.004 | 5.712 |
| 29A | 41.139 | 1659.8 | 28.513 | 796.9 |
| Name: LUDA 0024 Agricultural Land | | | | |
| TNMHC | 496.636 | 38552.6 | 226.087 | 3716.8 |
| Paraffins | 132.578 | 2299.8 | 103.226 | 1167.9 |
| Olefins | 293.542 | 24566.3 | 66.374 | 1533.0 |
| Aromatics | 70.777 | 956.3 | 56.446 | 480.3 |
| Methane | 262.423 | 2921.8 | 262.423 | 2921.8 |
| α-Pinene | 16.439 | 451.1 | 16.439 | 451.1 |
| β-Pinene | 2.757 | 14.539 | 2.757 | 14.5 |
| d-Limonene | 2.356 | 633.2 | 22.687 | 306.1 |
| Isoprene | 207.200 | 21376.2 | 0.000 | 0.0 |
| Myrcene | 0.423 | 0.597 | 0.340 | 0.326 |
| Unk. Terpenes | 0.113 | 0.210 | 0.113 | 0.210 |
| 21 | 11.751 | 88.8 | 8.162 | 42.8 |
| 23 | 2.559 | 5.649 | 1.780 | 2.729 |
| 24 | 0.253 | 1.042 | 0.253 | 1.042 |
| $\Delta^3$-Carene | 9.048 | 36.9 | 6.500 | 18.4 |

## LUDA Emission Factors
$\mu g/m^2/hr$

| | Day | | Night | |
|---|---|---|---|---|
| Compound | ER | $S^2$ | ER | $S^2$ |
| **Name: LUDA 0025 Cropland** | | | | |
| TNMHC | 828.958 | 150347.0 | 287.860 | 11004.3 |
| Paraffins | 192.063 | 8731.3 | 133.360 | 4203.8 |
| Olefins | 543.474 | 95482.5 | 89.136 | 3349.5 |
| Aromatics | 93.871 | 3678.3 | 65.209 | 1774.3 |
| Methane | 272.418 | 4431.1 | 272.418 | 4431.1 |
| d-Limonene | 64.872 | 2531.2 | 45.114 | 1222.8 |
| Isoprene | 414.400 | 85504.9 | 0.000 | 0.0 |
| Myrcene | 0.547 | 2.094 | 0.380 | 1.100 |
| 21 | 23.502 | 355.2 | 16.324 | 171.3 |
| 23 | 5.118 | 22.6 | 3.560 | 10.9 |
| $\Delta^3$-Carene | 16.663 | 143.0 | 11.567 | 69.0 |
| **Name: LUDA 0026 Pasture** | | | | |
| TNMHC | 988.706 | 124478.0 | 630.087 | 59514.7 |
| Paraffins | 204.894 | 8117.8 | 163.029 | 4121.0 |
| Olefins | 633.166 | 119002.0 | 349.052 | 56831.4 |
| Aromatics | 148.717 | 4194.4 | 116.793 | 2087.3 |
| Methane | 459.655 | 33823.1 | 456.881 | 33816.3 |
| α-Pinene | 191.095 | 42705.9 | 145.424 | 21627.6 |
| β-Pinene | 51.304 | 4337.1 | 37.718 | 2124.1 |
| d-Limonene | 15.149 | 211.9 | 10.590 | 102.8 |
| Isoprene | 148.629 | 4481.8 | 0.000 | 0.0 |
| Myrcene | 11.988 | 767.9 | 8.396 | 370.1 |
| Unk. Terpenes | 3.885 | 1229.2 | 2.826 | 587.6 |
| 21A | 0.366 | 0.0 | 0.255 | 0.0 |
| 17 | -0.013 | 0.0007 | -0.013 | 0.0007 |
| 18 | 0.060 | 0.023 | 0.052 | 0.014 |
| 20 | 0.011 | 0.004 | 0.007 | 0.002 |
| 21 | 44.736 | 22064.1 | 30.189 | 11071.7 |
| 22 | 2.360 | 72.6 | 1.625 | 34.7 |
| 23 | 0.164 | 0.243 | 0.115 | 0.118 |
| 24 | 0.494 | 3.802 | 0.494 | 3.802 |
| 27 | 3.787 | 273.9 | 2.621 | 131.2 |
| 28 | 0.186 | 0.070 | 0.129 | 0.034 |
| $\Delta^3$-Carene | 91.386 | 14622.9 | 63.755 | 7068.1 |
| 26A | 6.102 | 797.2 | 4.234 | 383.4 |
| 29A | 2.808 | 8.574 | 1.941 | 4.113 |
| **Name: LUDA 0027 Specialty Farms** | | | | |
| TNMHC | 87.200 | 401.1 | 87.200 | 401.1 |
| Paraffins | 54.520 | 378.9 | 54.520 | 378.9 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 32.720 | 147.3 | 32.720 | 147.3 |
| Methane | 375.700 | 18540.0 | 375.700 | 18540.0 |

## LUDA Emission Factors
μg/m²/hr

| Compound | Day ER | Day $S^2$ | Night ER | Night $S^2$ |
|---|---|---|---|---|
| **Name: LUDA 0028 Horticultural Farms** | | | | |
| TNMHC | 2006.520 | 122974.0 | 878.956 | 32111.4 |
| Paraffins | 393.924 | 4680.2 | 279.014 | 2214.9 |
| Olefins | 1197.720 | 101638.0 | 306.961 | 25277.4 |
| Aromatics | 412.204 | 1365.8 | 291.497 | 666.6 |
| Methane | 378.625 | 17725.0 | 367.795 | 17502.8 |
| α-Pinene | 163.826 | 10290.0 | 120.265 | 3431.7 |
| β-Pinene | 112.851 | 11526.2 | 80.900 | 5619.8 |
| d-Limonene | 14.538 | 158.4 | 10.104 | 76.9 |
| Isoprene | 753.571 | 52072.7 | 0.000 | 0.0 |
| Myrcene | 1.317 | 5.083 | 0.914 | 2.450 |
| Unk. Terpenes | 0.302 | 0.790 | 0.302 | 0.790 |
| 21A | 3.865 | 0.0 | 2.694 | 0.0 |
| 18 | 0.041 | 0.046 | 0.028 | 0.022 |
| 20 | 0.020 | 0.012 | 0.013 | 0.005 |
| 21 | 2.063 | 19.3 | 1.809 | 9.310 |
| 22 | 1.024 | 11.9 | 0.693 | 5.613 |
| 23 | 2.439 | 47.4 | 1.703 | 23.1 |
| 24 | 0.674 | 3.923 | 0.674 | 3.924 |
| 27 | 1.291 | 10.5 | 0.896 | 5.053 |
| 28 | 2.759 | 13.7 | 1.916 | 6.633 |
| 29 | 1.051 | 4.377 | 0.625 | 1.843 |
| Δ³-Carene | 20.165 | 834.6 | 14.149 | 402.9 |
| 26A | 1.450 | 11.9 | 1.004 | 5.712 |
| 29A | 41.139 | 1659.8 | 28.513 | 796.9 |
| **Name: LUDA 0029 Groves** | | | | |
| TNMHC | 5974.090 | 83781200.0 | 4199.180 | 40399500.0 |
| Paraffins | 1317.130 | 1558510.0 | 938.209 | 748416.0 |
| Olefins | 3352.490 | 68638800.0 | 2337.420 | 33109700.0 |
| Aromatics | 1311.640 | 1077280.0 | 927.075 | 519264.0 |
| Methane | 4505.220 | 52289100.0 | 4505.220 | 522891.0 |
| α-Pinene | 48.626 | 8745.0 | 39.061 | 5168.5 |
| β-Pinene | 2.780 | 63.8 | 2.780 | 63.8 |
| d-Limonene | 111.528 | 114893.0 | 77.638 | 55394.7 |
| Myrcene | 0.750 | 2.250 | 0.750 | 2.250 |
| Unk. Terpenes | 0.252 | 1.525 | 0.252 | 1.525 |
| 16 | 4.444 | 315.9 | 3.090 | 152.8 |
| 21 | 26.808 | 11151.0 | 18.629 | 5348.9 |
| 22 | 239.299 | 257860.0 | 166.247 | 124261.0 |
| 24 | 3001.780 | 61323300.0 | 2084.520 | 29570000.0 |
| 25 | 24.890 | 9915.2 | 17.280 | 4775.6 |
| 26 | 6.294 | 634.0 | 4.361 | 304.3 |
| Δ³-Carene | 3.269 | 30.5 | 3.207 | 30.2 |

## LUDA Emission Factors
$\mu g/m^2/hr$

| Compound | Day | | Night | |
|---|---|---|---|---|
| | ER | $S^2$ | ER | $S^2$ |
| **Name: LUDA 0031 Herbaceous Rangeland** | | | | |
| TNMHC | 1710.020 | 783922.0 | 834.917 | 84132.7 |
| Paraffins | 268.489 | 12016.8 | 205.846 | 5805.9 |
| Olefins | 1220.390 | 543581.0 | 463.762 | 58340.8 |
| Aromatics | 217.958 | 14837.7 | 162.950 | 7073.2 |
| Methane | 550.412 | 50488.4 | 543.934 | 49609.4 |
| α-Pinene | 244.493 | 27502.2 | 195.356 | 16492.4 |
| β-Pinene | 100.567 | 17147.0 | 73.888 | 8365.0 |
| d-Limonene | 19.903 | 271.1 | 13.889 | 132.8 |
| Isoprene | 593.021 | 425104.0 | 0.000 | 0.0 |
| Myrcene | 11.772 | 347.8 | 543.934 | 49609.4 |
| Unk. Terpenes | 1.191 | 368.1 | 1.068 | 175.1 |
| 21A | 0.732 | 0.0 | 0.510 | 0.0 |
| 17 | -0.008 | 0.0001 | -0.008 | 0.0001 |
| 18 | 0.684 | 13.292 | 0.470 | 6.235 |
| 20 | 0.316 | 3.050 | 0.213 | 1.430 |
| 21 | 59.199 | 15983.9 | 39.919 | 8020.9 |
| 22 | 16.252 | 3397.8 | 11.001 | 1596.0 |
| 23 | 0.163 | 0.080 | 0.114 | 0.039 |
| 24 | 1.157 | 14.4 | 1.157 | 14.4 |
| 27 | 2.872 | 56.590 | 1.988 | 27.1 |
| 28 | 0.185 | 0.023 | 0.128 | 0.011 |
| $\Delta^3$-Carene | 86.136 | 4518.2 | 60.227 | 2184.7 |
| 26A | 8.244 | 577.9 | 5.721 | 277.9 |
| 29A | 2.777 | 2.837 | 1.920 | 1.361 |
| **Name: LUDA 0032 Shrub & Brush Rangeland** | | | | |
| TNMHC | 4706.690 | 32608300.0 | 1062.720 | 1033410.0 |
| Paraffins | 625.703 | 459502.0 | 447.619 | 215213.0 |
| Olefins | 3411.640 | 21256100.0 | 137.535 | 26368.3 |
| Aromatics | 627.189 | 675885.0 | 476.619 | 318417.0 |
| Methane | 1215.170 | 1869980.0 | 118.475 | 1826360.0 |
| α-Pinene | 60.111 | 13699.1 | 58.064 | 13606.4 |
| β-Pinene | 14.839 | 583.4 | 13.059 | 529.0 |
| d-Limonene | 0.992 | 21.0 | 0.724 | 19.8 |
| Isoprene | 3226.450 | 20856600.0 | 0.000 | 0.0 |
| Myrcene | 0.0006 | 0.00001 | 0.0004 | 0.00006 |
| Unk. Terpenes | 0.948 | 12.7 | 0.948 | 12.7 |
| 21A | 0.177 | 0.0 | 0.123 | 0.0 |
| 18 | 4.918 | 661.0 | 3.320 | 310.0 |
| 20 | 2.355 | 151.7 | 1.590 | 71.1 |
| 21 | 0.067 | 0.040 | 0.046 | 194.3 |
| 22 | 110.800 | 168277.0 | 74.841 | 79035.7 |
| 23 | 2.289 | 47.2 | 1.598 | 23.0 |

## LUDA Emission Factors
$\mu g/m^2/hr$

| Compound | Day ER | Day $S^2$ | Night ER | Night $S^2$ |
|---|---|---|---|---|
| Name: LUDA 0032 Shrub 7 Brush Rangeland (cont'd) | | | | |
| 24 | 2.111 | 62.9 | 2.111 | 62.9 |
| 27 | 1.212 | 10.4 | 0.841 | 5.031 |
| 28 | 2.590 | 13.7 | 1.798 | 6.604 |
| 29 | 0.162 | 0.140 | 0.096 | 0.059 |
| $\Delta^3$-Carene | 3.355 | 24.4 | 2.803 | 18.9 |
| 26A | 1.361 | 11.9 | 0.943 | 5.688 |
| 29A | 38.666 | 1652.8 | 26.797 | 793.5 |
| Name: LUDA 0033 Mixed Rangeland | | | | |
| TNMHC | 1455.950 | 491083.0 | 10.066 | 67.7 |
| Paraffins | 248.474 | 7886.3 | 190.730 | 3851.6 |
| Olefins | 1009.940 | 337376.0 | 371.668 | 33858.7 |
| Aromatics | 195.347 | 9510.8 | 146.890 | 4556.2 |
| Methane | 511.907 | 34540.7 | 504.268 | 33965.6 |
| α-Pinene | 194.526 | 16529.1 | 159.041 | 11044.5 |
| β-Pinene | 76.162 | 8508.8 | 56.777 | 4196.6 |
| d-Limonene | 14.398 | 136.1 | 10.066 | 67.7 |
| Isoprene | 50.759 | 272376.0 | 0.000 | 0.0 |
| Myrcene | 8.377 | 181.8 | 5.880 | 33965.6 |
| Unk. Terpenes | 0.949 | 189.9 | 0.878 | 90.9 |
| 21A | 0.583 | 0.0 | 0.406 | 0.0 |
| 17 | -0.006 | 0.00005 | -0.006 | 0.00005 |
| 18 | 0.540 | 8.496 | 0.370 | 3.985 |
| 20 | 0.251 | 1.950 | 0.169 | 0.914 |
| 21 | 42.066 | 8467.8 | 28.366 | 4249.2 |
| 22 | 12.801 | 2169.9 | 8.664 | 1019.2 |
| 23 | 1.029 | 7.587 | 0.719 | 3.696 |
| 24 | 1.170 | 13.8 | 1.170 | 13.8 |
| 27 | 2.498 | 29.9 | 1.730 | 14.3 |
| 28 | 1.165 | 2.200 | 0.809 | 1.062 |
| 29 | 0.065 | 0.022 | 0.038 | 0.009 |
| $\Delta^3$-Carene | 61.675 | 2262.3 | 43.266 | 1095.2 |
| 26A | 6.406 | 308.0 | 4.444 | 148.1 |
| 29A | 17.402 | 265.8 | 12.058 | 127.6 |
| Name: LUDA 0041 Deciduous Forest | | | | |
| TNMHC | 6766.050 | 5955530.0 | 1566.530 | 441895.0 |
| Paraffins | 583.021 | 43139.4 | 414.970 | 20353.3 |
| Olefins | 5703.130 | 4909980.0 | 819.285 | 321585.0 |
| Aromatics | 470.809 | 29477.3 | 328.793 | 14063.7 |
| Methane | 876.217 | 190798.0 | 835.143 | 177365.0 |
| α-Pinene | 285.465 | 94877.6 | 230.086 | 57665.4 |
| β-Pinene | 225.108 | 51805.9 | 174.251 | 29980.7 |

## LUDA Emission Factors
μg/$m^2$/hr

| | Day | | Night | |
|---|---|---|---|---|
| Compound | ER | $S^2$ | ER | $S^2$ |
| Name: LUDA 0041 Deciduous Forest (cont'd) | | | | |
| d-Limonene | 29.723 | 753.1 | 20.671 | 375.1 |
| Isoprene | 4595.070 | 4286410.0 | 0.000 | 0.0 |
| Myrcene | 876.217 | 190798.0 | 10.778 | 1992.4 |
| Unk. Terpenes | -10.324 | 2445.8 | -6.672 | 1128.1 |
| 18 | 0.046 | 0.073 | 0.031 | 0.034 |
| 20 | 0.022 | 0.017 | 0.015 | 0.008 |
| 21 | 181.077 | 251991.0 | 122.792 | 126396.0 |
| 22 | 1.468 | 18.8 | 1.000 | 8.836 |
| 23 | 1.773 | 20.9 | 1.238 | 10.168 |
| 24 | 2.111 | 79.9 | 2.111 | 79.9 |
| 27 | 1.116 | 5.253 | 0.774 | 2.528 |
| 28 | 2.006 | 6.053 | 1.393 | 2.922 |
| 29 | 8.992 | 423.7 | 5.349 | 178.4 |
| $\Delta^3$-Carene | 75.683 | 10020.0 | 52.985 | 4844.3 |
| 26A | 21.124 | 9012.5 | 14.736 | 4334.2 |
| 29A | 30.053 | 731.5 | 20.848 | 351.2 |
| Name: LUDA 0042 Evergreen Forest | | | | |
| TNMHC | 5172.930 | 4174540.0 | 1925.350 | 1316290.0 |
| Paraffins | 564.633 | 44244.6 | 407.980 | 21497.0 |
| Olefins | 4203.920 | 3646710.0 | 1230.690 | 1185960.0 |
| Aromatics | 376.290 | 17378.5 | 268.465 | 8488.8 |
| Methane | 785.746 | 111900.0 | 762.483 | 108347.0 |
| α-Pinene | 639.467 | 444387.0 | 466.827 | 222247.0 |
| β-Pinene | 631.495 | 622767.0 | 448.389 | 301602.0 |
| d-Limonene | 76.744 | 8219.1 | 53.324 | 3966.8 |
| Isoprene | 2483.460 | 1204830.0 | 0.000 | 0.0 |
| Myrcene | 0.108 | 0.264 | 0.075 | 0.128 |
| Unk. Terpenes | 1.008 | 12.7 | 1.008 | 12.7 |
| 21A | 4.393 | 0.0 | 3.061 | 0.0 |
| 18 | 0.294 | 2.598 | 0.199 | 1.218 |
| 20 | 0.141 | 0.596 | 0.095 | 0.279 |
| 21 | 0.022 | 0.004 | 0.015 | 0.002 |
| 22 | 6.658 | 661.3 | 4.498 | 310.6 |
| 23 | 0.749 | 5.046 | 0.523 | 2.458 |
| 24 | 2.246 | 63.0 | 2.246 | 63.0 |
| 27 | 0.396 | 1.117 | 0.275 | 0.538 |
| 28 | 0.847 | 1.463 | 0.588 | 0.706 |
| 29 | 4.446 | 105.9 | 2.645 | 44.6 |
| $\Delta^3$-Carene | 128.591 | 45483.2 | 89.762 | 21938.6 |
| 26A | 0.445 | 1.270 | 0.308 | 0.608 |
| 29A | 12.366 | 176.6 | 8.580 | 84.8 |

## LUDA Emission Factors
$\mu g/m^2/hr$

| Compound | Day | | Night | |
|---|---|---|---|---|
| | ER | $S^2$ | ER | $S^2$ |
| Name: LUDA 0043 Mixed Forest | | | | |
| TNMHC | 5969.490 | 2532520.0 | 1745.940 | 439545.0 |
| Paraffins | 573.827 | 21846.0 | 411.475 | 10462.6 |
| Olefins | 4953.520 | 2139170.0 | 1024.990 | 376886.0 |
| Aromatics | 423.550 | 11713.9 | 298.629 | 5638.1 |
| Methane | 830.981 | 75674.5 | 798.813 | 71427.9 |
| α-Pinene | 462.466 | 134816.0 | 348.456 | 69977.9 |
| β-Pinene | 428.301 | 168643.0 | 311.320 | 82895.6 |
| d-Limonene | 53.234 | 2243.0 | 36.998 | 1085.5 |
| Isoprene | 3539.270 | 1372810.0 | 0.000 | 0.0 |
| Myrcene | 7.806 | 1030.3 | 5.426 | 498.1 |
| Unk. Terpenes | -4.658 | 614.625 | -2.832 | 285.2 |
| 21A | 2.196 | 0.0 | 1.531 | 0.0 |
| 18 | 0.170 | 0.668 | 0.115 | 0.313 |
| 20 | 0.081 | 0.153 | 0.055 | 0.072 |
| 21 | 90.549 | 62997.8 | 61.404 | 31599.1 |
| 22 | 4.063 | 170.0 | 2.749 | 79.9 |
| 23 | 1.261 | 6.479 | 0.880 | 3.156 |
| 24 | 2.179 | 35.7 | 2.179 | 35.7 |
| 27 | 0.756 | 1.593 | 0.525 | 0.767 |
| 28 | 1.427 | 1.879 | 0.991 | 0.907 |
| 29 | 6.719 | 132.4 | 3.997 | 55.8 |
| $\Delta^3$-Carene | 102.137 | 13875.9 | 71.374 | 6695.7 |
| 26A | 10.842 | 2253.4 | 7.522 | 1083.7 |
| 29A | 21.210 | 227.0 | 14.714 | 109.0 |
| Name: LUDA 0051 Streams, Canals | | | | |
| TNMHC | 159.817 | 1655.7 | 159.817 | 1655.7 |
| Paraffins | 68.869 | 209.2 | 68.869 | 209.2 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 90.839 | 1607.8 | 90.839 | 1607.8 |
| Methane | 5994.600 | 11837700.0 | 5994.600 | 11837700.0 |
| 17 | -0.065 | 0.017 | -0.065 | 0.017 |
| 18 | 0.185 | 0.136 | 0.185 | 0.136 |
| Name: LUDA 0052 Lakes | | | | |
| TNMHC | 145.887 | 1647.2 | 145.887 | 1647.2 |
| Paraffins | 63.499 | 180.4 | 63.499 | 180.4 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 82.279 | 1601.8 | 82.279 | 1601.8 |
| Methane | 5636.200 | 11644400.0 | 5636.200 | 11644400.0 |
| 17 | -0.065 | 0.017 | -0.065 | 0.017 |
| 18 | 0.185 | 0.136 | 0.185 | 0.136 |

## LUDA Emission Factors
$\mu g/m^2/hr$

| Compound | Day |  | Night |  |
|---|---|---|---|---|
|  | ER | $S^2$ | ER | $S^2$ |
| Name: LUDA 0053 Reservoirs |  |  |  |  |
| TNMHC | 145.887 | 1647.2 | 145.887 | 1647.2 |
| Paraffins | 63.499 | 180.4 | 63.499 | 180.4 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 82.279 | 1601.8 | 82.279 | 1601.8 |
| Methane | 5636.200 | 11644400.0 | 5636.200 | 11644400.0 |
| 17 | -0.065 | 0.017 | -0.065 | 0.017 |
| 18 | 0.185 | 0.136 | 0.185 | 0.136 |
| Name: LUDA 0054 Bays & Estuaries |  |  |  |  |
| TNMHC | 168.242 | 1405.6 | 168.242 | 1405.6 |
| Paraffins | 94.671 | 571.3 | 94.671 | 571.3 |
| Olefins | 6.375 | 81.3 | 67.375 | 81.3 |
| Aromatics | 67.301 | 250.4 | 67.301 | 250.4 |
| Methane | 406.068 | 4745.8 | 406.068 | 4745.8 |
| α-Pinene | 1.632 | 5.330 | 1.632 | 5.330 |
| Myrcene | 1.550 | 4.805 | 1.550 | 4.805 |
| Terpinolene | 1.550 | 4.805 | 1.550 | 4.805 |
| 10A | 0.674 | 9.572 | 0.674 | 9.572 |
| 22 | 1.134 | 10.4 | 1.134 | 10.4 |
| 23 | 0.0005 | 0.00001 | 0.0005 | 0.00001 |
| 24 | 0.044 | 0.094 | 0.044 | 0.094 |
| Name: LUDA 055 Gulf |  |  |  |  |
| TNMHC | 134.169 | 675.3 | 134.169 | 675.3 |
| Paraffins | 74.213 | 301.4 | 74.213 | 301.4 |
| Olefins | 6.375 | 81.3 | 6.375 | 81.3 |
| Aromatics | 53.639 | 102.6 | 53.639 | 102.6 |
| Methane | 314.810 | 4787.8 | 314.810 | 4787.8 |
| α-Pinene | 1.632 | 5.330 | 1.632 | 5.330 |
| Myrcene | 1.550 | 4.805 | 1.550 | 4.805 |
| Terpinolene | 1.550 | 4.805 | 1.550 | 4.805 |
| 10A | 0.270 | 2.084 | 0.270 | 2.084 |
| 22 | 0.548 | 2.566 | 0.548 | 2.566 |
| 23 | 0.0002 | 0.00003 | 0.0002 | 0.00003 |
| 24 | 0.022 | 0.024 | 0.022 | 0.024 |
| Name: LUDA 0061 Deciduous Forest Wetland |  |  |  |  |
| TNMHC | 6807.000 | 15479100.0 | 3817.460 | 7280810.0 |
| Paraffins | 993.542 | 464183.0 | 701.483 | 223343.0 |
| Olefins | 5018.710 | 14504500.0 | 2561.450 | 6758540.0 |
| Aromatics | 801.235 | 265039.0 | 560.589 | 127612.0 |
| Methane | 1341.940 | 1671330.0 | 1326.060 | 1670900.0 |
| α-Pinene | 1043.900 | 3289920.0 | 792.606 | 1641350.0 |

## LUDA Emission Factors
$\mu g/m^2/hr$

| Compound | Day | | Night | |
|---|---|---|---|---|
| | ER | $S^2$ | ER | $S^2$ |
| **Name: LUDA 0061 Deciduous Forest Wetlands (cont'd)** | | | | |
| α-Pinene | 36.196 | 10634.7 | 35.908 | 6716.5 |
| d-Limonene | 94.761 | 14562.2 | 65.819 | 7019.8 |
| Isoprene | 1385.170 | 593605.0 | 0.000 | 0.0 |
| Myrcene | 137.484 | 143666.0 | 2536.145 | 6758540.0 |
| Unk. Terpenes | -7.315 | 131337.0 | -3.972 | 61584.2 |
| 17 | -0.065 | 0.017 | -0.065 | 0.017 |
| 18 | 0.185 | 0.136 | 0.185 | 0.136 |
| 21 | 772.050 | 7219980.0 | 520.262 | 3623100.0 |
| 22 | 14.364 | 4090.2 | 9.945 | 1960.3 |
| 23 | 1.486 | 19.9 | 1.037 | 9.681 |
| 27 | 29.484 | 16475.4 | 20.406 | 7899.0 |
| 28 | 1.681 | 5.763 | 1.167 | 2.782 |
| $\Delta^3$-Carene | 708.361 | 1021560.0 | 491.185 | 493595.0 |
| 26A | 109.550 | 261089.0 | 76.014 | 125559.0 |
| 29A | 25.392 | 701.3 | 17.552 | 336.4 |
| **Name: LUDA 0071 Dry Salt Flats** | | | | |
| TNMHC | 349.000 | 0.0 | 349.000 | 0.0 |
| Paraffins | 157.000 | 0.0 | 157.000 | 0.0 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 192.000 | 0.0 | 192.000 | 0.0 |
| Methane | 380.000 | 0.0 | 380.000 | 0.0 |
| **Name: LUDA 0072 Beaches** | | | | |
| TNMHC | 303.206 | 92.7 | 303.206 | 92.7 |
| Paraffins | 134.881 | 7.901 | 134.881 | 7.901 |
| Olefins | 8.925 | 159.3 | 8.925 | 159.3 |
| Aromatics | 159.414 | 9.478 | 159.414 | 9.478 |
| Methane | 383.430 | 372.7 | 383.430 | 372.7 |
| α-Pinene | 2.286 | 10.4 | 2.286 | 10.4 |
| Myrcene | 2.170 | 9.418 | 2.170 | 9.418 |
| Terpinolene | 2.170 | 9.418 | 2.170 | 9.418 |
| 22 | 0.643 | 4.544 | 0.643 | 4.544 |
| **Name: LUDA 0073 Sand Non-Beaches** | | | | |
| TNMHC | 349.000 | 0.0 | 349.000 | 0.0 |
| Paraffins | 157.000 | 0.0 | 157.000 | 0.0 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 192.000 | 0.0 | 192.000 | 0.0 |
| Methane | 380.000 | 0.0 | 380.000 | 0.0 |

LUDA Emission Factors
$\mu g/m^2/hr$

| Compound | Day | | Night | |
|---|---|---|---|---|
| | ER | $S^2$ | ER | $S^2$ |
| Name: LUDA 0074 Bare Rock | | | | |
| TNMHC | 0.000 | 0.0 | 0.000 | 0.0 |
| Paraffins | 0.000 | 0.0 | 0.000 | 0.0 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 0.000 | 0.0 | 0.000 | 0.0 |
| Methane | 0.000 | 0.0 | 0.000 | 0.0 |
| Name: LUDA 0075 Strip Mines etc. | | | | |
| TNMHC | 349.000 | 0.0 | 349.000 | 0.0 |
| Paraffins | 157.000 | 0.0 | 157.000 | 0.0 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 192.000 | 0.0 | 192.000 | 0.0 |
| Methane | 380.000 | 0.0 | 380.000 | 0.0 |
| Name: LUDA 0076 Transition | | | | |
| TNMHC | 349.000 | 0.0 | 349.000 | 0.0 |
| Paraffins | 157.000 | 0.0 | 157.000 | 0.0 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 192.000 | 0.0 | 192.000 | 0.0 |
| Methane | 380.000 | 0.0 | 380.000 | 0.0 |
| Name: LUDA 0077 Mixed Barren Land | | | | |
| TNMHC | 349.000 | 0.0 | 349.000 | 0.0 |
| Paraffins | 157.000 | 0.0 | 157.000 | 0.0 |
| Olefins | 0.000 | 0.0 | 0.000 | 0.0 |
| Aromatics | 192.000 | 0.0 | 192.000 | 0.0 |
| Methane | 380.000 | 0.0 | 380.000 | 0.0 |
| Name: LUDA 0421 Planted Pine | | | | |
| TNMHC | 2907.450 | 5963810.0 | 2018.240 | 2873070.0 |
| Paraffins | 390.590 | 136662.0 | 271.161 | 65783.7 |
| Olefins | 2308.020 | 5013140.0 | 1603.650 | 2421690.0 |
| Aromatics | 196.709 | 35647.3 | 136.647 | 17228.2 |
| Methane | 507.806 | 323268.0 | 507.806 | 323268.0 |
| α-Pinene | 735.799 | 479851.0 | 510.840 | 230925.0 |
| β-Pinene | 726.948 | 1120640.0 | 504.812 | 540113.0 |
| Myrcene | 0.052 | 0.080 | 0.037 | 0.039 |
| -Carene | 287.247 | 339642.0 | 199.373 | 163738.0 |
| Name: LUDA 0612 Forested Evergreen Wetland | | | | |
| TNMHC | 6541.230 | 8091040.0 | 2870.010 | 1636140.0 |
| Paraffins | 839.900 | 123869.0 | 582.862 | 52715.4 |

LUDA Emission Factors
$\mu g/m^2/hr$

| Compound | Day ER | Day $S^2$ | Night ER | Night $S^2$ |
|---|---|---|---|---|
| Name: LUDA 0612 Forested Evergreen Wetland (cont'd) | | | | |
| Olefins | 4986.700 | 5842400.0 | 1801.960 | 1327970.0 |
| Aromatics | 710.833 | 60369.4 | 486.162 | 27008.8 |
| Methane | 1371.550 | 171970.0 | 1313.560 | 170583.0 |
| α-Pinene | 561.752 | 380081.0 | 428.794 | 187960.0 |
| β-Pinene | 223.896 | 73288.2 | 161.981 | 35489.4 |
| d-Limonene | 79.378 | 2915.2 | 55.145 | 1408.0 |
| Isoprene | 2426.390 | 2786120.0 | 0.000 | 0.0 |
| Myrcene | 72.629 | 28500.3 | 50.457 | 13777.1 |
| Unk. Terpenes | -25.141 | 18225.6 | -16.531 | 8388.3 |
| 21A | 1.464 | 0.0 | 1.020 | 0.0 |
| 17 | -0.026 | 0.001 | -0.026 | 0.001 |
| 18 | 0.164 | 0.295 | 0.135 | 0.143 |
| 20 | 0.043 | 0.066 | 0.029 | 0.031 |
| 21 | 624.177 | 1696390.0 | 422.627 | 850920.0 |
| 22 | 7.151 | 198.9 | 4.919 | 94.6 |
| 23 | 1.185 | 5.028 | 0.828 | 2.450 |
| 24 | 1.235 | 19.7 | 1.235 | 19.7 |
| 27 | 9.402 | 505.5 | 6.507 | 242.1 |
| 28 | 1.341 | 1.458 | 0.931 | 0.704 |
| 29 | 0.248 | 0.330 | 0.148 | 0.139 |
| $\Delta^3$-Carene | 348.901 | 79326.8 | 242.253 | 38303.4 |
| 26A | 74.700 | 60686.5 | 51.832 | 29184.5 |
| 29A | 21.708 | 182.5 | 15.035 | 87.6 |
| Name: LUDA 0621 Nonforested Wetlands | | | | |
| TNMHC | 198.987 | 3929.7 | 198.987 | 3929.7 |
| Paraffins | 75.907 | 212.6 | 75.907 | 212.6 |
| Olefins | 29.250 | 2083.0 | 29.250 | 2083.0 |
| Aromatics | 93.689 | 1609.2 | 93.689 | 1609.2 |
| Methane | 6025.910 | 11838200.0 | 6025.910 | 11838200.0 |
| α-Pinene | 24.230 | 1429.0 | 24.230 | 1429.0 |
| β-Pinene | 3.917 | 37.9 | 3.917 | 37.9 |
| 17 | -0.065 | 0.017 | -0.065 | 0.017 |
| 18 | 0.185 | 0.136 | 0.185 | 0.136 |
| Name: LUDA 6121 Mangroves | | | | |
| TNMHC | 765.266 | 150551.0 | 561.323 | 73002.6 |
| Paraffins | 439.131 | 83182.7 | 321.487 | 40567.2 |
| Olefins | 3.109 | 118.9 | 2.180 | 57.4 |
| Aromatics | 323.738 | 38429.5 | 238.036 | 18563.0 |
| Methane | 1017.190 | 600835.0 | 101.719 | 600835.0 |

# APPENDIX D

## INTRODUCTION

This appendix lists the daily (24 hour) emissions of each LUDA category summed over the entire study area. The total estimated area and the area % covered by each LUDA category are also listed. Area values are in units of $km^2$. Emission rates are in units of Kg/24 hrs.

# APPENDIX D

## Total Emissions By LUDA Category (kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0011 Residential | Area: 711 km$^2$ | % of Total Area: 14.6 |
| TNMHC | 24,631 | 3,361 |
| Paraffins | 5,744 | 709 |
| Olefins | 12,844 | 3,041 |
| Aromatics | 6,007 | 385 |
| Methane | 6,371 | 1,602 |
| α-Pinene | 2,425 | 1,070 |
| β-Pinene | 1,654 | 1,118 |
| d-Limonene | 210 | 131 |
| Isoprene | 6,433 | 1,948 |
| Myrcene | 19 | 23 |
| Unk. Terpenes | 5 | 11 |
| 21A | 56 | --- |
| 21 | 38 | 46 |
| 22 | 14 | 36 |
| 23 | 35 | 72 |
| 24 | 12 | 24 |
| 27 | 19 | 34 |
| 28 | 40 | 39 |
| 29 | 14 | 21 |
| $\Delta^3$-Carene | 293 | 300 |
| 26A | 21 | 36 |
| 29A | 595 | 423 |
| Name: LUDA 0021 Cropland Pasture | Area: 32 km$^2$ | % of Total Area: 0.7 |
| TNMHC | 291 | 85 |
| Paraffins | 88 | 22 |
| Olefins | 156 | 69 Aromatics |
| 46 | 15 | |
| Methane | 204 | 34 |
| α-Pinene | 28 | 28 |
| β-Pinene | 5 | 5 |
| d-Limonene | 21 | 12 |
| Isoprene | 79 | 55 |
| Myrcene | --- | --- |
| 21 | 8 | 4 |
| 23 | 2 | 1 |
| $\Delta^3$-Carene | 6 | 3 |

## Total Emissions By LUDA Category
## (kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0022 Orchards, Vineyards, Nurseries Area: 7 km$^2$ % of Total: 0.1 | | |
| TNMHC | 234 | 32 |
| Paraffins | 55 | 7 |
| Olefins | 122 | 29 |
| Aromatics | 57 | 4 |
| Methane | 60 | 15 |
| α-Pinene | 23 | 10 |
| β-Pinene | 16 | 11 |
| d-Limonene | 2 | 1 |
| Isoprene | 61 | 18 |
| $\Delta^3$-Carene | 3 | 3 |
| 29A | 6 | 4 |
| Name: LUDA 0024 Agricultural Land Area: 6 km$^2$ % of Total Area: 0.1 | | |
| TNMHC | 56 | 16 |
| Paraffins | 18 | 5 |
| Olefins | 28 | 12 |
| Aromatics | 10 | 3 |
| Methane | 40 | 6 |
| α-Pinene | 3 | 2 |
| β-Limonene | 4 | 2 |
| Isoprene | 16 | 11 |
| 21 | 2 | 1 |
| $\Delta^3$-Carene | 1 | 1 |
| Name: LUDA 0025 Cropland Area: 221 km$^2$ % of Total Area: 4.6 | | |
| TNMHC | 2,964 | 1,066 |
| Paraffins | 864 | 302 |
| Olefins | 1,679 | 834 |
| Aromatics | 422 | 196 |
| Methane | 1,446 | 250 |
| d-Limonene | 292 | 163 |
| Isoprene | 1,100 | 776 |
| Myrcene | 2 | 5 |
| 21 | 106 | 61 |
| 23 | 23 | 15 |
| $\Delta^3$-Carene | 75 | 39 |

Total Emissions By LUDA Category
(kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0026 Pasture | Area: 719 km$^2$ | % of Total: 14.8 |
| TNMHC | 13,973 | 3,703 |
| Paraffins | 3,176 | 955 |
| Olefins | 8,478 | 3,620 |
| Aromatics | 2,292 | 684 |
| Methane | 7,911 | 2,245 |
| α-Pinene | 2,905 | 2,189 |
| β-Pinene | 768 | 694 |
| d-Limonene | 222 | 153 |
| Isoprene | 1,283 | 578 |
| Myrcene | 176 | 291 |
| Unknown terpenes | 58 | 358 |
| 21A | 5 | --- |
| 18 | 1 | 2 |
| 21 | 648 | 1,571 |
| 22 | 34 | 89 |
| 23 | 2 | 5 |
| 24 | 9 | 24 |
| 27 | 55 | 174 |
| 28 | 3 | 3 |
| $\Delta^3$-Carene | 1,339 | 1,271 |
| 26A | 89 | 30 |
| 29A | 41 | 31 |
| Name: LUDA 0027 Specialty Farms | Area: 6 km$^2$ | % of Total: 0.1 |
| TNMHC | 12 | 2 |
| Paraffins | 8 | 2 |
| Olefins | 0 | --- |
| Aromatics | 5 | 1 |
| Methane | 53 | 14 |
| Name: LUDA 0028 Horticultural Farms | Area: 11.4 km$^2$ | % of Total: 0.2 |
| TNMHC | 393 | 54 |
| Paraffins | 92 | 11 |
| Olefins | 205 | 49 |
| Aromatics | 96 | 6 |
| Methane | 102 | 26 |
| α-Pinene | 39 | 17 |
| β-Pinene | 26 | 18 |
| d-Limonene | 3 | 2 |
| Isoprene | 103 | 31 |
| $\Delta^3$-Carene | 5 | 5 |
| 29A | 9 | 7 |

## Total Emissions By LUDA Category
(kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0029 Groves | Area: 286 km$^2$ | % of Total: 5.9 |
| TNMHC | 34,925 | 38,257 |
| Paraffins | 7,743 | 5,214 |
| Olefins | 19,534 | 34,629 |
| Aromatics | 7,686 | 4,338 |
| Methane | 30,933 | 35,108 |
| α-Pinene | 301 | 405 |
| β-Pinene | 19 | 39 |
| d-Limonene | 649 | 1,417 |
| Myrcene | 5 | 7 |
| Unknown terpenes | 2 | 6 |
| 16 | 26 | 74 |
| 21 | 156 | 441 |
| 22 | 1,392 | 2,122 |
| 24 | 17,462 | 32,730 |
| 25 | 145 | 416 |
| 26 | 37 | 105 |
| $\Delta^3$-Carene | 22 | 27 |
| Name: LUDA 0031 Herbaceous Rangeland | Area: 503 km$^2$ | % of Total: 10.4 |
| TNMHC | 15,364 | 5,625 |
| Paraffins | 2,864 | 806 |
| Olefins | 10,168 | 4,684 |
| Aromatics | 2,300 | 894 |
| Methane | 6,607 | 1,910 |
| α-Pinene | 2,655 | 1,266 |
| β-Pinene | 1,053 | 964 |
| d-Limonene | 204 | 121 |
| Isoprene | 3,580 | 3,936 |
| Myrcene | 121 | 137 |
| Unknown terpenes | 14 | 141 |
| 21A | 8 | --- |
| 18 | 7 | 27 |
| 20 | 3 | 13 |
| 21 | 598 | 935 |
| 22 | 165 | 427 |
| 23 | 2 | 2 |
| 24 | 14 | 32 |
| 27 | 29 | 55 |
| 28 | 2 | 1 |
| $\Delta^3$-Carene | 884 | 494 |
| 26A | 84 | 177 |
| 29A | 28 | 12 |

## Total Emissions By LUDA Category
(kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0032 | Area: 2 km$^2$ | % of Total: 0.1 |
| TNMHC | 171 | 172 |
| Paraffins | 32 | 24 |
| Olefins | 105 | 137 |
| Aromatics | 34 | 30 |
| Methane | 71 | 57 |
| α-Pinene | 4 | 5 |
| β-Pinene | 1 | 1 |
| Isoprene | 96 | 136 |
| 22 | 6 | 15 |
| 29A | 2 | 1 |
| Name: LUDA 0033 Mixed Rangeland | Area: 34 km$^2$ | % of Total: <0.1 |
| TNMHC | 9 | 3 |
| Paraffins | 2 | <1 |
| Olefins | 6 | 2 |
| Aromatics | 1 | <1 |
| Methane | 4 | 1 |
| α-Pinene | 1 | <1 |
| β-Pinene | 1 | <1 |
| Isoprene | 2 | 2 |
| Name: LUDA 0041 Deciduous Forest | Area: 0.7 km$^2$ | % of Total: <1 |
| TNMHC | 67 | 20 |
| Paraffins | 8 | 2 |
| Olefins | 53 | 19 |
| Aromatics | 6 | 2 |
| Methane | 14 | 5 |
| α-Pinene | 4 | 3 |
| β-Pinene | 3 | 2 |
| Isoprene | 37 | 17 |
| 21 | 2 | 5 |
| $\Delta^3$-Carene | 1 | 1 |

## Total Emissions By LUDA Category

(kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0042 Evergreen Forest | Area: 223 km$^2$ | % of Total: 4.6 |
| TNMHC | 18,974 | 6,264 |
| Paraffins | 2,600 | 685 |
| Olefins | 14,527 | 5,876 |
| Aromatics | 1,723 | 430 |
| Methane | 4,138 | 1,254 |
| α-Pinene | 2,957 | 2,182 |
| β-Pinene | 2,887 | 2,570 |
| d-Limonene | 348 | 295 |
| Isoprene | 6,638 | 2,934 |
| Unknown terpenes | 5 | 13 |
| 21A | 20 | --- |
| 18 | 1 | 5 |
| 22 | 30 | 83 |
| 23 | 3 | 7 |
| 24 | 12 | 30 |
| 27 | 2 | 3 |
| 28 | 4 | 4 |
| 29 | 19 | 33 |
| $\Delta^3$-Carene | 584 | 694 |
| 26A | 2 | 4 |
| 29A | 56 | 43 |
| Name: LUDA 0043 Mixed Forest | Area: 2 km$^2$ | % of Total: <.1 TNMHC |
| 167 | 37 | |
| Paraffins | 21 | 4 |
| Olefins | 129 | 34 |
| Aromatics | 16 | 3 |
| Methane | 35 | 8 |
| α-Pinene | 18 | 10 |
| β-Pinene | 16 | 11 |
| d-Limonene | 2 | 1 |
| Isoprene | 76 | 25 |
| 21 | 3 | 7 |
| $\Delta^3$-Carene | 4 | 3 |
| Name: LUDA 0051 Streams, Canals | Area: 12.7 km$^2$ | % of Total: 0.3 |
| TNMHC | 49 | 9 |
| Paraffins | 21 | 3 |
| Olefins | 0 | 0 |
| Aromatics | 28 | 9 |
| Methane | 1,829 | 742 |

## Total Emissions By LUDA Category

(kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0052 Lakes | Area: 63 $km^2$ | % of Total: 1.3 |
| TNMHC | 222 | 44 |
| Paraffins | 97 | 14 |
| Olefins | 0 | 0 |
| Aromatics | 125 | 43 |
| Methane | 8,658 | 3,668 |
| Name: LUDA 0053 Reserviors | Area: 14 $km^2$ | % of Total: 0.3 |
| TNMHC | 50 | 10 |
| Paraffins | 22 | 3 |
| Olefins | 0 | 0 |
| Aromatics | 28 | 10 |
| Methane | 1,933 | 827 |
| Name: LUDA 0054 Bays & Estuaries | Area: 742 $km^2$ | % of Total: 15.3 |
| TNMHC | 2,998 | 472 |
| Paraffins | 1,687 | 301 |
| Olefins | 114 | 114 |
| Aromatics | 1,199 | 199 |
| Methane | 7,236 | 868 |
| α-Pinene | 29 | 29 |
| β-Pinene | 0 | 0 |
| d-Limonene | 0 | 0 |
| Isoprene | 0 | 0 |
| Myrcene | 28 | 28 |
| Terpinolene | 28 | 28 |
| 10A | 12 | 39 |
| 22 | 20 | 41 |
| Name: LUDA 0055 Gulf | Area: 460 $km^2$ | % of Total: 9.5 |
| TNMHC | 1,481 | 203 |
| Paraffins | 819 | 135 |
| Olefins | 70 | 70 |
| Aromatics | 592 | 79 |
| Methane | 3,474 | 540 |
| α-Pinene | 18 | 18 |
| Myrcene | 17 | 17 |
| Terpinolene | 17 | 17 |
| 10A | 3 | 11 |
| 22 | 6 | 12 |

## Total Emissions By LUDA Category

(kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0061 Deciduous Forest Wetland | Area: 11 km$^2$ | % of Total: 0.2 |
| TNMHC | 1,334 | 599 |
| Paraffins | 213 | 104 |
| Olefins | 952 | 579 |
| Aromatics | 171 | 79 |
| Methane | 335 | 203 |
| $\alpha$-Pinene | 231 | 279 |
| $\beta$-Pinene | 9 | 17 |
| d-Limonene | 20 | 18 |
| Isoprene | 174 | 97 |
| Myrcene | 29 | 58 |
| Unknown terpenes | -1 | 55 |
| 21 | 163 | 413 |
| 22 | 3 | 10 |
| 27 | 6 | 20 |
| $\Delta^3$-Carene | 151 | 155 |
| 26A | 23 | 78 |
| 29A | 5 | 4 |
| Name: LUDA 0071 Dry Salt Flats | Area: <0.1 km$^2$ | % of Total: <.1 |
| TNMHC | 0 | 0 |
| Paraffins | 0 | 0 |
| Olefins | 0 | 0 |
| Aromatics | 0 | 0 |
| Methane | 0 | 0 |
| Name: LUDA 0072 Beaches | Area: 8 km$^2$ | % of Total: 0.2 |
| TNMHC | 61 | 1 |
| Paraffins | 27 | <1 |
| Olefins | 2 | 2 |
| Aromatics | 32 | <1 |
| Methane | 77 | 3 |
| Name: LUDA 0073 Sand Non-beaches | Area: 1 km$^2$ | % of Total: <.1 |
| TNMHC | 12 | --- |
| Paraffins | 6 | --- |
| Olefins | 0 | --- |
| Aromatics | 7 | --- |
| Methane | 13 | --- |

## Total Emissions By LUDA Category

(kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0074 Bare Rock | Area: 0.7 km$^2$ | % of Total: <1 |
| TNMHC | 0 | 0 |
| Paraffins | 0 | 0 |
| Olefins | 0 | 0 |
| Aromatics | 0 | 0 |
| Methane | 0 | 0 |
| Name: LUDA 0075 Strip Mines, etc. | Area: 40 km$^2$ | % of Total: 0.8 |
| TNMHC | 337 | 0 |
| Paraffins | 152 | 0 |
| Olefins | 0 | 0 |
| Aromatics | 186 | 0 |
| Methane | 367 | 0 |
| Name: LUDA 0076 Transition | Area: 47 km$^2$ | % of Total: 1.0 |
| TNMHC | 389 | 0 |
| Paraffins | 175 | 0 |
| Olefins | 0 | 0 |
| Aromatics | 214 | 0 |
| Methane | 424 | 0 |
| Name: LUDA 0077 Mixed Barren Land | Area: <0.1 km$^2$ | % of Total: <1 |
| TNMHC | 0 | 0 |
| Paraffins | 0 | 0 |
| Olefins | 0 | 0 |
| Aromatics | 0 | 0 |
| Methane | 0 | 0 |
| Name: LUDA 0421 Planted Pine | Area: 21 km$^2$ | % of Total: 0.4 |
| TNMHC | 1,257 | 758 |
| Paraffins | 169 | 115 |
| Olefins | 998 | 696 |
| Aromatics | 85 | 59 |
| Methane | 259 | 205 |
| $\alpha$-Pinene | 318 | 215 |
| $\beta$-Pinene | 314 | 329 |
| d-Limonene | 78 | 80 |
| $\Delta^3$-Carene | 124 | 181 |

## Total Emissions By LUDA Category

(kg/24 hr)

| Compound | ER | Std. Dev. |
|---|---|---|
| Name: LUDA 0612 Evergreen Wetland Forests | Area: 310 $km^2$ | % of Total: 6.4 |
| TNMHC | 35,041 | 11,612 |
| Paraffins | 5,297 | 1,565 |
| Olefins | 25,276 | 9,970 |
| Aromatics | 4,457 | 1,101 |
| Methane | 9,997 | 2,179 |
| α-Pinene | 3,688 | 2,806 |
| β-Pinene | 1,437 | 1,228 |
| d-Limonene | 501 | 245 |
| Isoprene | 9,034 | 6,215 |
| Myrcene | 458 | 766 |
| Unknown terpenes | -155 | 607 |
| 21A | 9 | 0 |
| 18 | 1 | 2 |
| 21 | 3,898 | 5,924 |
| 22 | 45 | 64 |
| 23 | 7 | 10 |
| 24 | 9 | 23 |
| 27 | 59 | 102 |
| 28 | 8 | 5 |
| 29 | 1 | 3 |
| $\Delta^3$-Carene | 2,201 | 1,277 |
| 26A | 471 | 1,116 |
| 29A | 137 | 61 |
| Name: LUDA 0621 Non-Forested Wetland | Area: 34 $km^2$ | % of Total: 0.7 |
| TNMHC | 164 | 37 |
| Paraffins | 63 | 8 |
| Olefins | 24 | 27 |
| Aromatics | 77 | 23 |
| Methane | 4,962 | 2,004 |
| α-Pinene | 20 | 22 |
| β-Pinene | 3 | 4 |
| Name: LUDA 6121 Mangroves | Area: 64 $km^2$ | % of Total: 1.3 |
| TNMHC | 1,021 | 364 |
| Paraffins | 585 | 271 |
| Olefins | 4 | 10 |
| Aromatics | 432 | 184 |
| Methane | 1,565 | 844 |

# APPENDIX E

## INTRODUCTION

This appendix outlines the order of events for the performance of this project. A sample field work schedule is also included. This information may be of importance for those interested in a more detailed interpretation of the data presented in this report or to those involved in planning similar research programs in the future.

# APPENDIX E

## Field Sampling Schedule

### 1.1 ORDER OF EVENTS

In February 1977, prior to initiation of the field program, the study area was visited by the principal investigator. During this planning trip the local air pollution control agencies were visited and informed of the impending study. Arrangements were made with the Hillsborough County Environmental Protection Commission for the location of our field laboratory. Laboratory and storage facilities were also provided. The Pinellis County Department of Environmental Management arranged a helicopter flight and a ground tour over the study area to help define the major vegetation types and to determine potential sampling sites. Land use planning maps (LUDA Maps), which defined vegetation in the study area, were obtained from the Tampa Bay Regional Planning Council.

The WSU mobile laboratory and a four-man crew arrived in Tampa on March 15, 1977. The period from March 15 to March 31 was used to optimize the analytical instrumentation and to perform the necessary checks on the sampling equipment. The field sampling program began on April 1. On April 28 and 29 the field site was visited by EPA project officers to review the sampling procedures and to discuss the sampling strategy. In June two additional personnel were added to the staff. One person had extensive experience as a laboratory assistant for the chemistry department at the University of South Florida. He therefore assisted in routine analysis, allowing other experienced WSU personnel to begin data reduction. The other person had previous experience in the air pollution field, and was a doctoral candidate in urban ecology. She was therefore assigned the task of quantitating the vegetative leaf biomass in the study area.

On June 16, 1977 the Tampa field site was visited by Ron McHenry and Carl Sova EPA Region IV, Dave Tingey EPA Corvalis, and Leslie Dunn EPA Las Vegas. The meeting was initiated so that results of the Phase I sampling program could be discussed and recommendations concerning Phase II could be made. The main points of the meeting were:

1. Mr. Dunn was to insure that all of the contractors involved in the Ozone Modeling Study including WSU would be furnished with the exact grid coordinates of the study area.

2. Based upon the results of Phase I the following re-distribution of our sample effort was recommended:

   a) Due to the large emissions from Gum trees, the Oak Gum Cypress vegetation groups were to be considered to consist primarily of Gum and Cypress.

   b) The marine samples were to be cut by 50 samples. This would allow an additional 25 samples to be distributed among other vegetation types.

   c) Ten samples were to be cut from citrus and ten samples from Mangrove vegetation types.

   d) Ten additional samples were to be made of the representative shrub group. The samples will concentrate upon Black Willow, Wax Myrtle, and Persimmon.

   e) Ten samples were to be made of freshwater marsh and wetland vegetation.

   f) Twenty five samples were to be collected of the predominate row crops available at that time, especially tomatoes and beans if possible.

   g) The Oak-Hickory group would be considered to consist primarily of Oak.

h) Some of the species sampled diurnally in Phase I would again be sampled in Phase II.

3. The problem of isolating sample variables which affect emission rates was discussed. It was pointed out that Corvalis should soon have a system of enclosed plexiglass environmentally controlled chambers for use in the project. It was decided that in order to separate the effects that the variables of illumination, temperature and soil water potential might have on emission rates, chamber studies should be performed. The vegetation type chosen for the first chamber tests was oak. Oaks were chosen because WSU sampling had shown that oaks exhibited a definite diurnal cycle of emissions. WSU had also found that the emission components of oaks were relatively simple consisting almost entirely of large amounts of Isoprene (in daylight hours), thus the analytical methodology required could be relatively simple. Rasmussen, (1970) had previously demonstrated that Isoprene production in plants was light dependent. Field samples collected during Phase I illustrated that temperature and soil moisture may also affect Isoprene production.

Phase II of the field study began on June 19 and was completed by August 1, 1977. In all, 632 natural emission samples were collected requiring over 1000 analysis for each of the heavy hydrocarbon, light hydrocarbon, methane and $C_2$ hydrocarbon groups.

### .2 TYPICAL WORK SCHEDULE

On typical sampling days, the G.C.s were standardized at about 6 AM. Analysis of samples would then begin. Field samples were usually collected between 6 AM and 7 PM, although each week two vegetation species/sample types were sampled every 6 hours for 30 hours. At least eight vegetation samples were collected daily. Each vegetation sample required a background sample and an emission rate sample; therefore at least 16 cans had to be analyzed daily. Two days each week (usually Saturday and Sunday) twenty samples were collected from Tampa Bay and the Gulf of Mexico. The sampling schedule necessitated operation of the G.C.s on a 16 to 24-hour basis six days per week.

commerce early in the morning so that emission rate samples could be collected and returned throughout the day. Testing at WSU had indicated that minimum hydrocarbon losses would be expected even for samples stored for 24 hours.

The field schedule outlined allowed each vegetation association to be sampled approximately four times weekly. Appendix A lists the species sampled, the number of times each was sampled, and the mean and standard error of the emission rates standardized to 30°C (day) and 25°C (night) for each species. The emission rates are given in terms of the micrograms emission (compound)/g leaf biomass/hr of paraffins, olefins, aromatics, methane, TNMHC and for each major peak. "Flat samples" (bay, pasture, etc.) are in micrograms/$m^2$/hr.